Bilag 4

Supplerende materiale fra Viegaard Stutteri og Aarhus Universitet Foulum

Anna Dorte Nørgaard

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Emne:	SV: Vindmøller ved Låstrup
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Kœre Karl Johan Legård,

Det er en stor opgave du har sat mig på.
Jeg forstår godt at Viborg Kommune vil forsøge at hæve en grøn energy til 6% men i dette tilfælde mister Kommunen også mere end 30 arbejdsplads i landistriktet, og et stutteri det bygget op over de sidste 30 år. Hvis dette Vindmølle project gennemføres hvem er da erstatnings pligtig overfor Viegård Stutteri?
Har du brug for mere info eller tid til et besøg er du velkommen til at kontakte mig.

Venlig Hilsen
John Byrialsen

p.s. Appendix 6.2 kommer senere

Fra: Karl Johan Legaard [mailto:kjl@viborg.dk]
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Emne: Vindmøller ved Låstrup

Kære John Byrialsen

Tak for dit høringssvar til fordebat for vindmølleplanlægning ved Låstrup. Forvaltningen behandler p.t. alle indkomne høringssvar, hvorefter de forelægges for Klima og Miljøudvalget.

Du har inviteret os til et møde om en række relevante emner, men forinden et eventuelt møde vil vi gerne have belyst flere af de forhold, der kan blive berørt af vindmøller, som du og dine ansatte og tilknyttede på Viegaard Stutteri har fremsendt beskrivelser af. Vi håber at du vil være os behjælpelig med at belyse det bedst muligt, og at du vil koordinere en tilbagemelding omkring nedenstående.

For at kunne vurdere konkrete afstande har forvaltningen behov for at vide, hvor stutteriet har udendørs faciliteter til hestene, herunder folde, ridebaner, rideruter mv. Flere skriver, at I rider i området omkring de planlagte vindmøller og mellem gårdene. I den sammenhæng vil vi gerne have et kort med indtegnede faciliteter og ride ruter.

Tilsvarende vil vi gerne have et kort, der illustrerer de konkrete planer for en ny stadion og andre faciliteter og ændringer herunder forslaget til en flytning af Vievej.

Flere høringssvar med reference til Viegaard Stutteri henviser til erfaringer med vindmøller andre steder uden konkrete angivelser af steder og dokumentation. Vi vil gerne have en samlet tilbagemelding med links eller lignende til konkret dokumentation eller undersøgelser fra disse steder for at kunne dokumentere dette i sagsbehandlingen:

- Der er henvist til erfaringer med vindmøller i Tyskland. Vi vil gerne have konkrete henvisninger til dokumentation fra dette område.

- Der er refereret til erfaringer med vindmøller i Xingjian. Vi vil gerne have konkrete henvisninger til dokumentation fra dette område.
- Der henvist til, at i hele Europa tages der hensyn til ride ruter, og at flere og flere myndigheder tager hensyn til stutterier ved stillingtagen til vindmølleprojekter. Vi vil gerne have henvisninger til dokumentation og konkrete myndighedsafgørelser?
- Der er henvist til et stutteri, hvor vindmøller resulterede i, at man måtte opgive salg af heste. Vi vil gerne have en konkret henvisning til stedet og den myndighed, der har behandlet sagen.

Den dokumentation, I fremsender, vil blive forelagt politikerne i forbindelse med sagsbehandlingen af vindmølleprojektet.

Vi vil sætte pris på en tilbagemelding med de nævnte informationer inden den 12. oktober 2016, for at det kan indgå i den politiske behandling. Alternativt vil vi gerne have en tilbagemelding om, hvornår vi kan forvente en tilbagemelding.

Vi vil i øvrigt tage kontakt til Aarhus Universitet Foulum med hensyn til de forsøg universitetet har og planlægger på Viegaard Stutteri.

Med venlig hilsen

Karl Johan Legaard
Planchef

Viborg Kommune
Teknik & Miljø
Plan
Prinsens Alle 5
8800 Viborg
Direkte tlf.: 87 87 55 50

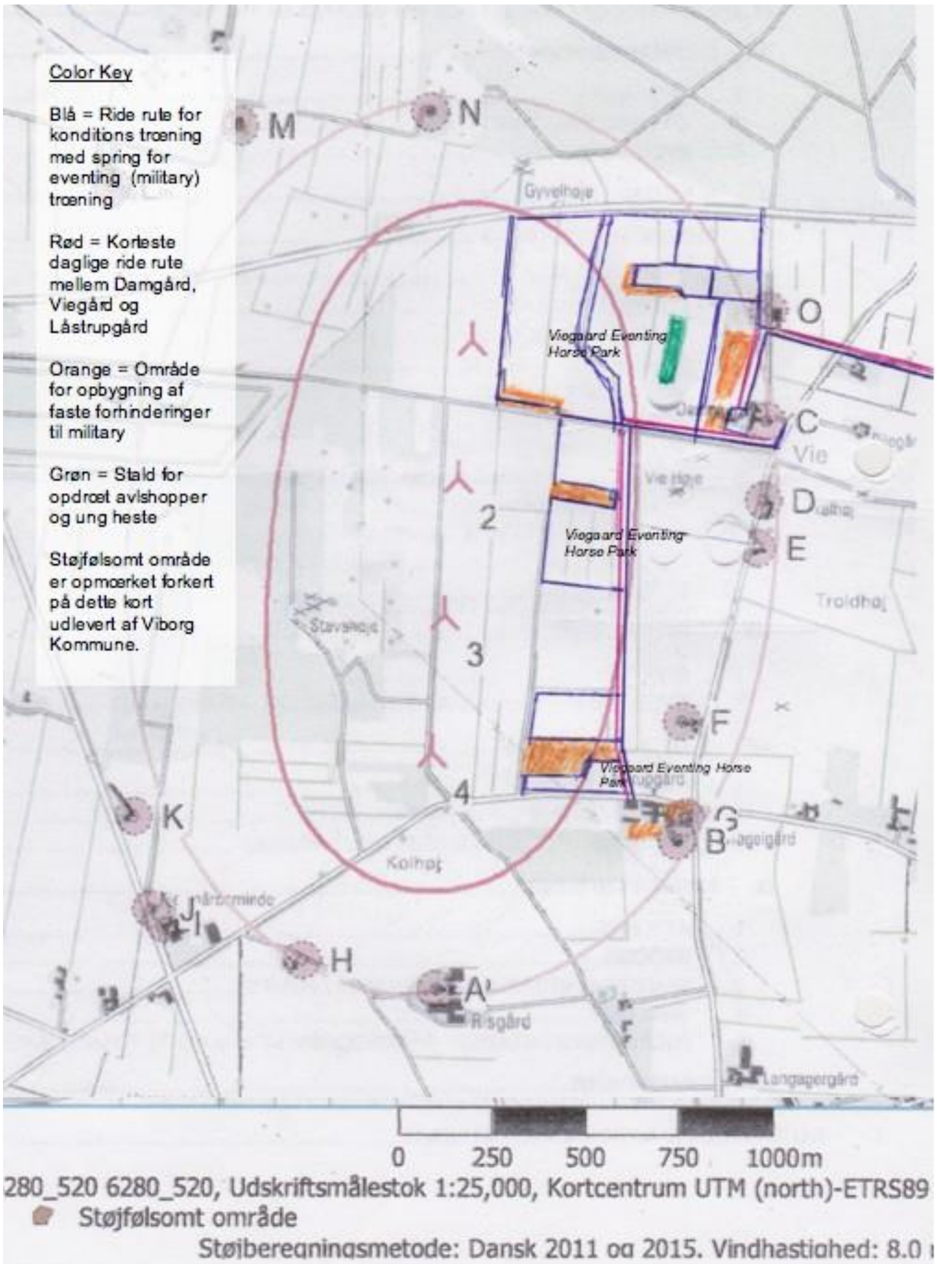
www.viborg.dk

14 October 2016

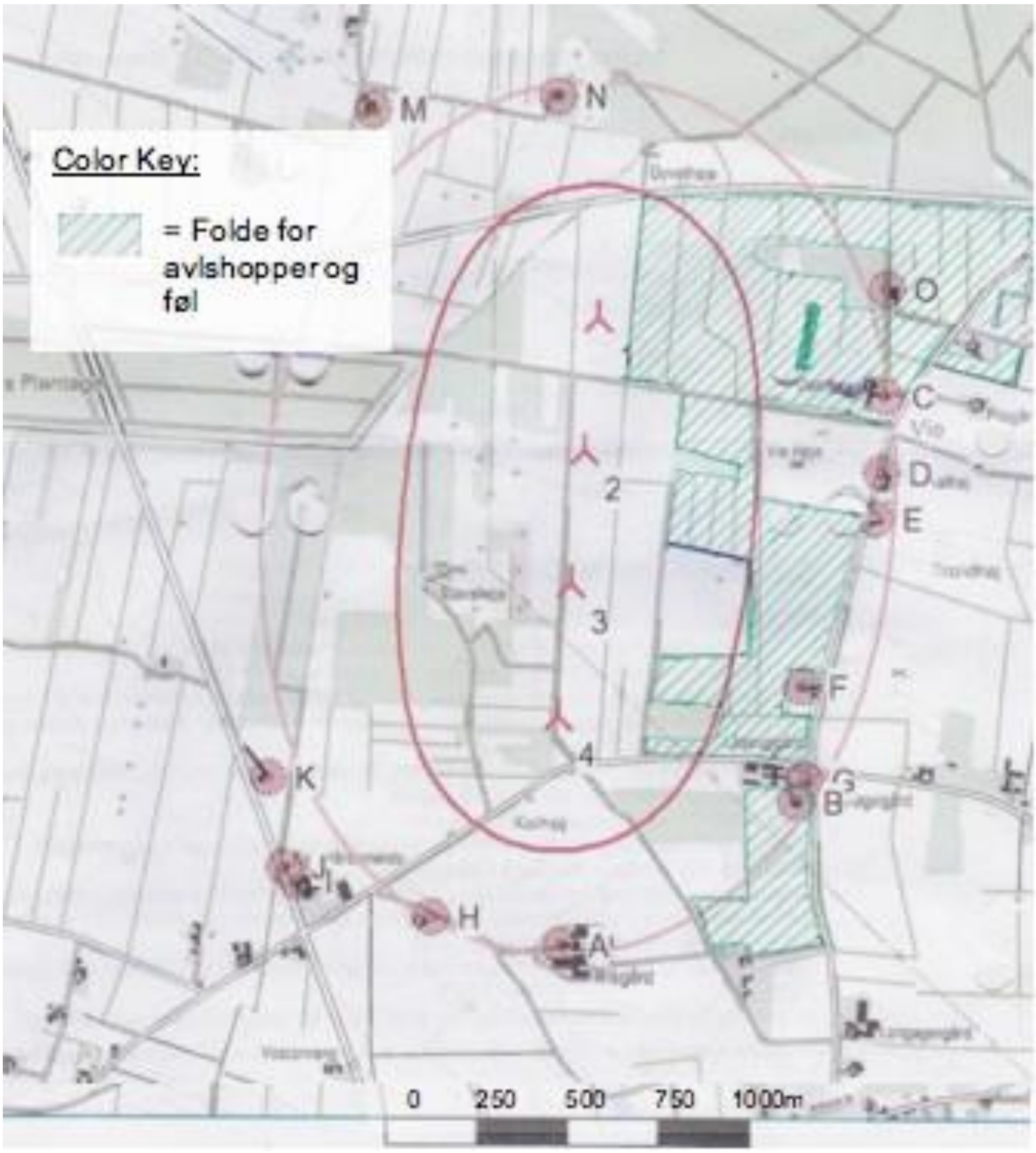
Viegård imod vindmøller

1.

1.1 Kort over ride rute og military forhindringer og park for eventing show

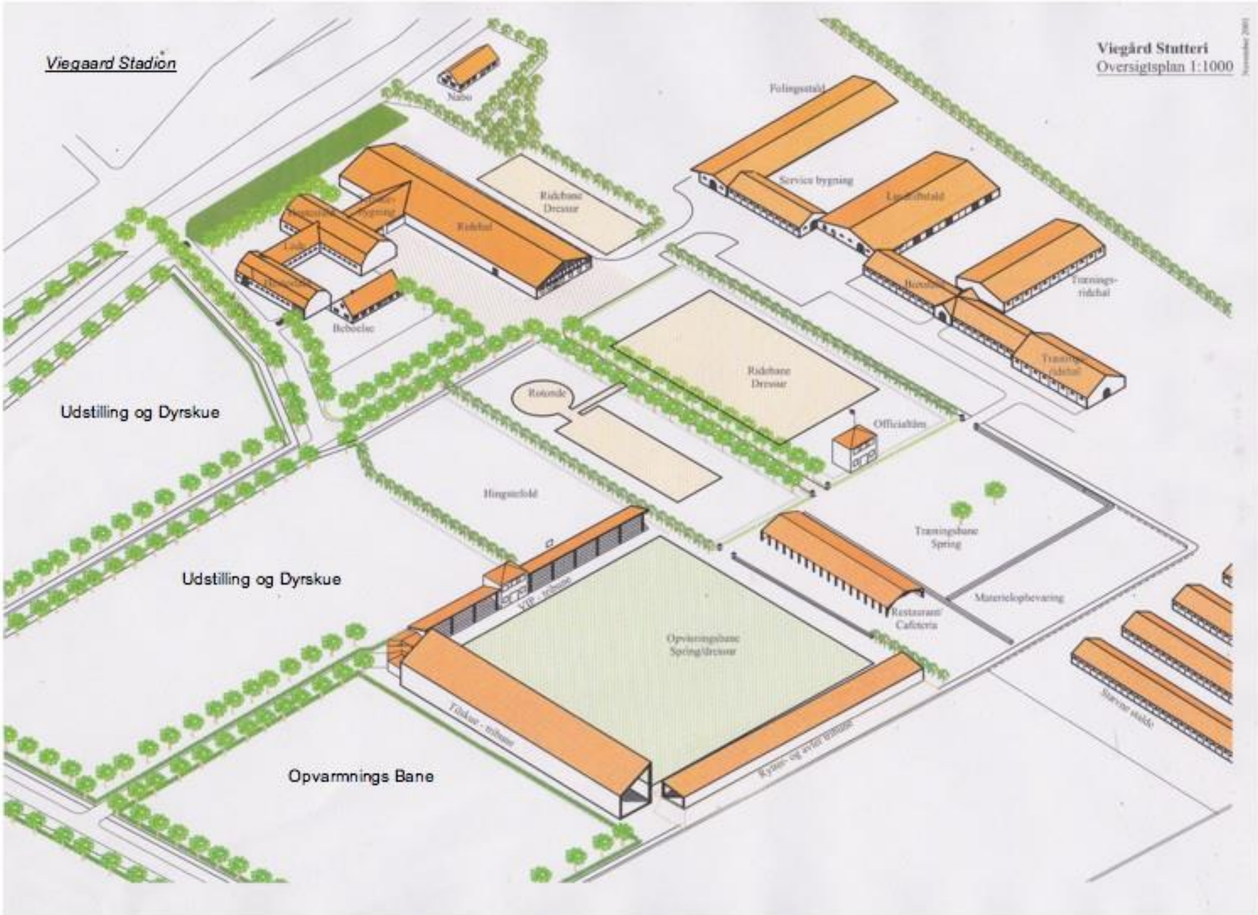


1.2 Kort over folk for avlshopper og føl



1.3 Dressur og spring bane ligger ved husene på Viegård, Damgård, Låstrupgård og Røgilgård.

1.4 Plan Viegård Stadion og Vievej




Viegård Entrance


Viegård Stadion View
Viegård Stutteri
Perspektiv


Plan For Avlshopper
Viegård Stutteri
Oversigtsplan 1:2000
nuvœrende stald for
avlshopper
Kommende stald for
avlshopper

2. Viegård Stutteri medarbejder kan dokumentere følgende:

2.1 Vedr. Tyskland får vi tilsendt documentations materiale
Mht til afstanden mellem vindmøller og huse/ virksomhed bliver denne evalueret i hvert enkelt tilfælde og afstanden varriere efter virksomhedens følsomhed overfor støj vibrationer og skygger 600m til 3000m er sikkerheds afstanden i Tyskland.

2.2 Vedr. Polen er der 20 Maj 2016 vedtaget ny lov om afstand mellem vindmølle og beboelse eller gårde denne afstand skal være mindst 10x vindmøllens højde incl. vinger (Låstrup projected ville kræve minimum 1560m til hus)
Se venligst polsk lovgivning vedlagt. Se appendix 1.1-1.6

2.3 Vedr. Scotland er der et krav på 2000m afstand.

2.4 Vedr. Xinjiang Kina er der krav på 2000m afstand, se appendix 2

2.5 Vi kan oplyse at alle lande vurdere det konkrete sted om der for eksempel er en lokal plan for ridestadion, equestrian træningsenter, beboere avlsgård eller en arbejdesplads hvor der kan opstå sikkerhedsmæssige problemer, for at blåstemple en hav vindmølle park.

2.6 Se Vindmølle lukker kursuscenter. Vindmølle lukker kursus og træningsenter da bølgerne fra vindmølle påvirker kursister og hestene negativt. Se appendix 3.1-3.2

2.7 I Californien har en heste avler mistet 6 ud af 8 føl ved abort eller hoppen ikke gav mælk til føllet. Se appendix 4.1-4.4

2.8 I Portugal har et stutteri tæt ved en vindmølle park fået aborte problemer og deformation af føllenes ben. Se appendix 5.1-5.11

2.9 I Danmark har en mink avler i Vest Jylland fået deformeret mink pga vindmøller.

2.10 Venligst læs dyrlæge (6.1), forskere fra Foulum (6.2), trænerer (6.3), professionelle rytterer (6.4-6.5), dansk ride forbund elite chef (6.6), dansk ride instruktør formand (6.7), Viegård Stutteri direktør og John Byrialsens kommentar (6.8). Se appendix 6.1-6.8

2.11 Hvem vil påstå at de ikke erfarligt at ride gennem disse skygger på forskellige heste. Se video

APPENDIX1.1

According to Chapter 2 Art. 4.1. of polish law from 20 May 2016 about investment in wind energy station the distance between windmill and buildings where people live or mixed function buildings (stables or farms with rooms for people) has to be equal or longer than 10 times of high of windmill with blades. Distance to nature protection objects is also 10 times of high of windmill.

APPENDIX1.2

DZIENNIK USTAW
RZECZYPOSPOLITEJ POLSKIEJ

Warszawa, dnia 1 lipca 2016 r.

Poz. 961

USTAWA

z dnia 20 maja 2016 r.

o inwestycjach w zakresie elektrowni wiatrowych[1)]

Rozdział 1
Przepisy ogólne

Art. 1. 1. Ustawa określa warunki i tryb lokalizacji i budowy elektrowni wiatrowych oraz warunki lokalizacji elektrowni wiatrowych w sąsiedztwie istniejącej albo planowanej zabudowy mieszkaniowej.

2. Ustawy nie stosuje się do inwestycji realizowanych i użytkowanych na obszarach morskich Rzeczypospolitej Polskiej, w rozumieniu ustawy z dnia 21 marca 1991 r. o obszarach morskich Rzeczypospolitej Polskiej i administracji morskiej (Dz. U. z 2013 r. poz. 934 i 1014, z 2015 r. poz. 1642 oraz z 2016 r. poz. 266 i 542).

Art. 2. Użyte w ustawie określenia oznaczają:

1) elektrownia wiatrowa – budowlę w rozumieniu przepisów prawa budowlanego, składającą się co najmniej z fundamentu, wieży oraz elementów technicznych, o mocy większej niż moc mikroinstalacji w rozumieniu art. 2 pkt 19 ustawy z dnia 20 lutego 2015 r. o odnawialnych źródłach energii (Dz. U. poz. 478 i 2365 oraz z 2016 r. poz. 925);

2) elementy techniczne – wirnik z zespołem łopat, zespół przeniesienia napędu, generator prądotwórczy, układy sterowania i zespół gondoli wraz z mocowaniem i mechanizmem obrotu.

Rozdział 2
Lokalizacja

Art. 3. Lokalizacja elektrowni wiatrowej następuje wyłącznie na podstawie miejscowego planu zagospodarowania przestrzennego, o którym mowa w art. 4 ust. 1 ustawy z dnia 27 marca 2003 r. o planowaniu i zagospodarowaniu przestrzennym (Dz. U. z 2016 r. poz. 778 i 904), zwanego dalej „planem miejscowym".

Art. 4. 1. Odległość, w której mogą być lokalizowane i budowane:

1) elektrownia wiatrowa – od budynku mieszkalnego albo budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, oraz

2) budynek mieszkalny albo budynek o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa – od elektrowni wiatrowej

– jest równa lub większa od dziesięciokrotności wysokości elektrowni wiatrowej mierzonej od poziomu gruntu do najwyższego punktu budowli, wliczając elementy techniczne, w szczególności wirnik wraz z łopatami (całkowita wysokość elektrowni wiatrowej).

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1) Niniejszą ustawą zmienia się ustawy: ustawę z dnia 7 lipca 1994 r. – Prawo budowlane, ustawę z dnia 27 marca 2003 r. o planowaniu i zagospodarowaniu przestrzennym oraz ustawę z dnia 3 października 2008 r. o udostępnianiu informacji o środowisku i jego ochronie, udziale społeczeństwa w ochronie środowiska oraz o ocenach oddziaływania na środowisko.

APPENDIX1.3

2. Odległość, o której mowa w ust. 1, wymagana jest również przy lokalizacji i budowie elektrowni wiatrowej od form ochrony przyrody, o których mowa w art. 6 ust. 1 pkt 1–3 i 5 ustawy z dnia 16 kwietnia 2004 r. o ochronie przyrody (Dz. U. z 2015 r. poz. 1651, 1688 i 1936 oraz z 2016 r. poz. 422), oraz od leśnych kompleksów promocyjnych, o których mowa w art. 13b ust. 1 ustawy z dnia 28 września 1991 r. o lasach (Dz. U. z 2015 r. poz. 2100 oraz z 2016 r. poz. 422, 586 i 903), przy czym ustanawianie tych form ochrony przyrody oraz leśnych kompleksów promocyjnych nie wymaga zachowania odległości, o której mowa w ust. 1.

3. Odległość, o której mowa w ust. 1, nie jest wymagana przy przebudowie, nadbudowie, rozbudowie, remoncie, montażu lub odbudowie budynku mieszkalnego albo budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa.

Art. 5. 1. Przez odległość, o której mowa w art. 4 ust. 1, rozumie się najkrótszy odcinek pomiędzy:

1) rzutem poziomym istniejącego budynku mieszkalnego albo istniejącego budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, albo

2) granicą terenu objętego decyzją o warunkach zabudowy, o której mowa w art. 4 ust. 2 pkt 2 i w art. 59 ust. 1 ustawy z dnia 27 marca 2003 r. o planowaniu i zagospodarowaniu przestrzennym, zwaną dalej „decyzją WZ", dotyczącą inwestycji, o której mowa w pkt 1, na którym możliwa jest lokalizacja tej inwestycji, albo

3) linią rozgraniczającą teren, którego sposób zagospodarowania określony w planie miejscowym dopuszcza realizację inwestycji, o której mowa w pkt 1,

a:

4) okręgiem, którego promień jest równy połowie średnicy wirnika wraz z łopatami, a środek jest środkiem okręgu opisanego na obrysie wieży istniejącej elektrowni wiatrowej, albo

5) linią rozgraniczającą teren, którego sposób zagospodarowania określony w planie miejscowym dopuszcza budowę elektrowni wiatrowej.

2. Przez obiekty budowlane, o których mowa w ust. 1 pkt 1 i 4, rozumie się również obiekty budowlane objęte decyzją o pozwoleniu na budowę albo zgłoszeniem, wobec którego organ administracji architektoniczno-budowlanej nie wniósł sprzeciwu.

3. Przez odległość, o której mowa w art. 4 ust. 2, rozumie się najkrótszy odcinek łączący punkt na granicy obszaru, dla którego ustanowiono formę ochrony przyrody, o której mowa w art. 6 ust. 1 pkt 1–3 i 5 ustawy z dnia 16 kwietnia 2004 r. o ochronie przyrody, lub leśnego kompleksu promocyjnego, o którym mowa w art. 13b ust. 1 ustawy z dnia 28 września 1991 r. o lasach, i odpowiednio: okrąg albo linię, o których mowa w ust. 1 pkt 4 i 5. Przepis ust. 2 stosuje się.

Art. 6. Odległość określoną zgodnie z art. 4 uwzględniają:

1) organy gminy – przy sporządzaniu oraz uchwalaniu studium uwarunkowań i kierunków zagospodarowania przestrzennego gminy albo jego zmiany;

2) organy gminy oraz wojewoda – przy sporządzaniu oraz uchwalaniu albo przyjmowaniu planu miejscowego albo jego zmiany;

3) organy gminy i wojewoda – przy wydawaniu decyzji o warunkach zabudowy;

4) organy administracji architektoniczno-budowlanej – przy wydawaniu pozwolenia na budowę oraz ocenie zasadności wniesienia sprzeciwu wobec zgłoszenia;

5) organy związku metropolitalnego – przy sporządzaniu oraz uchwalaniu studium ramowego uwarunkowań i kierunków zagospodarowania przestrzennego związku metropolitalnego albo jego zmiany;

6) organy województwa – przy sporządzaniu oraz uchwalaniu planu zagospodarowania przestrzennego województwa albo jego zmiany;

7) organy wydające decyzje o środowiskowych uwarunkowaniach – przy wydawaniu tych decyzji.

Art. 7. 1. Plan miejscowy przewidujący lokalizację elektrowni wiatrowej:

1) określa maksymalną całkowitą wysokość elektrowni wiatrowej;

2) sporządza się co najmniej dla obszaru, na którym, zgodnie z art. 4 ust. 1, nie mogą być zlokalizowane nowe budynki mieszkalne albo budynki o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, a którego granice są wyznaczane z uwzględnieniem maksymalnej całkowitej wysokości elektrowni wiatrowej określonej w tym planie.

2. W uzasadnieniu dołączanym do projektu uchwały w sprawie przystąpienia do sporządzania planu miejscowego przewidującego lokalizację elektrowni wiatrowej zamieszcza się w szczególności maksymalną całkowitą wysokość elektrowni wiatrowej, która zostanie określona w tym planie.

Art. 8. W sprawach nieuregulowanych w niniejszej ustawie stosuje się przepisy ustawy z dnia 27 marca 2003 r. o planowaniu i zagospodarowaniu przestrzennym oraz ustawy z dnia 7 lipca 1994 r. – Prawo budowlane (Dz. U. z 2016 r. poz. 290).

Rozdział 3

Zmiany w przepisach obowiązujących

Art. 9. W ustawie z dnia 7 lipca 1994 r. – Prawo budowlane (Dz. U. z 2016 r. poz. 290) wprowadza się następujące zmiany:

1) w art. 3 pkt 3 otrzymuje brzmienie:

„3) budowli – należy przez to rozumieć każdy obiekt budowlany niebędący budynkiem lub obiektem małej architektury, jak: obiekty liniowe, lotniska, mosty, wiadukty, estakady, tunele, przepusty, sieci techniczne, wolno stojące maszty antenowe, wolno stojące trwale związane z gruntem tablice reklamowe i urządzenia reklamowe, budowle ziemne, obronne (fortyfikacje), ochronne, hydrotechniczne, zbiorniki, wolno stojące instalacje przemysłowe lub urządzenia techniczne, oczyszczalnie ścieków, składowiska odpadów, stacje uzdatniania wody, konstrukcje oporowe, nadziemne i podziemne przejścia dla pieszych, sieci uzbrojenia terenu, budowle sportowe, cmentarze, pomniki, a także części budowlane urządzeń technicznych (kotłów, pieców przemysłowych, elektrowni jądrowych i innych urządzeń) oraz fundamenty pod maszyny i urządzenia, jako odrębne pod względem technicznym części przedmiotów składających się na całość użytkową;”;

2) w art. 82 ust. 3 po pkt 5a dodaje się pkt 5b w brzmieniu:

„5b) elektrowni wiatrowych, w rozumieniu art. 2 pkt 1 ustawy z dnia 20 maja 2016 r. o inwestycjach w zakresie elektrowni wiatrowych (Dz. U. poz. 961);”;

3) w załączniku do ustawy w tabeli wiersz „Kategoria XXIX” otrzymuje brzmienie:

		Współczynnik wielkości obiektu (w) (wysokość w m)			
		≤ 20	> 20–50	> 50–100	> 100
Kategoria XXIX – wolno stojące kominy i maszty oraz elektrownie wiatrowe	10,0	1,0	1,5	2,0	2,5

Art. 10. W ustawie z dnia 27 marca 2003 r. o planowaniu i zagospodarowaniu przestrzennym (Dz. U. z 2016 r. poz. 778 i 904) w art. 15 dodaje się ust. 4 w brzmieniu:

„4. Plan miejscowy przewidujący możliwość lokalizacji budynków umożliwia lokalizację urządzenia wytwarzającego energię z odnawialnych źródeł energii, wykorzystującego energię wiatru, o mocy nie większej niż moc mikroinstalacji w rozumieniu art. 2 pkt 19 ustawy z dnia 20 lutego 2015 r. o odnawialnych źródłach energii również w przypadku innego przeznaczenia terenu niż produkcyjne, chyba że ustalenia planu miejscowego zakazują lokalizacji takich urządzeń.”.

Art. 11. W ustawie z dnia 3 października 2008 r. o udostępnianiu informacji o środowisku i jego ochronie, udziale społeczeństwa w ochronie środowiska oraz o ocenach oddziaływania na środowisko (Dz. U. z 2016 r. poz. 353 i 831) w art. 75 w ust. 1 w pkt 1 w lit. p średnik zastępuje się przecinkiem i dodaje się lit. r w brzmieniu:

„r) elektrowni wiatrowych, o których mowa w art. 2 pkt 1 ustawy z dnia 20 maja 2016 r. o inwestycjach w zakresie elektrowni wiatrowych (Dz. U. poz. 961);”.

Rozdział 4

Przepisy przejściowe i końcowe

Art. 12. W przypadku elektrowni wiatrowych użytkowanych w dniu wejścia w życie ustawy, niespełniających wymogów określonych w art. 4, dopuszcza się jedynie przeprowadzenie remontu oraz wykonywanie innych czynności niezbędnych do prawidłowego użytkowania elektrowni, z wyłączeniem działań prowadzących do zwiększenia parametrów użytkowych elektrowni lub zwiększenia jej oddziaływań na środowisko.

Art. 13. 1. Pozwolenia na budowę dotyczące budynku mieszkalnego albo budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, wydane przed dniem wejścia w życie ustawy, zachowują moc.

2. Pozwolenia na budowę dotyczące elektrowni wiatrowych, wydane przed dniem wejścia w życie ustawy oraz wydane na podstawie postępowania, o którym mowa w ust. 3, zachowują moc, o ile w ciągu 3 lat od dnia wejścia w życie ustawy wydana zostanie decyzja o pozwoleniu na użytkowanie.

3. Postępowania w przedmiocie pozwolenia na budowę, wszczęte i niezakończone do dnia wejścia w życie ustawy, prowadzi się na podstawie przepisów dotychczasowych.

4. Zgłoszenia budowy, o której mowa w art. 29 ust. 1 pkt 1a ustawy z dnia 7 lipca 1994 r. – Prawo budowlane, w stosunku do których organ przed dniem wejścia w życie ustawy nie wniósł sprzeciwu, pozostają skuteczne.

5. Zgłoszenia budowy, o której mowa w art. 29 ust. 1 pkt 1a ustawy z dnia 7 lipca 1994 r. – Prawo budowlane, dokonane przed dniem wejścia w życie ustawy, dla których do dnia wejścia w życie ustawy nie upłynął termin na wniesienie sprzeciwu, ocenia się według przepisów dotychczasowych.

6. Wojewódzki inspektor nadzoru budowlanego nakazuje rozbiórkę wybudowanej części obiektu budowlanego, w przypadku nieuzyskania decyzji o pozwoleniu na użytkowanie, o której mowa w ust. 2, na koszt inwestora, chyba że inwestor uzyska – w terminie roku od dnia utraty mocy pozwolenia na budowę – nowe pozwolenie na budowę dotyczące tej elektrowni.

Art. 14. 1. Postępowania w przedmiocie wydania decyzji WZ, dotyczące budynku mieszkalnego albo budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, wszczęte i niezakończone do dnia wejścia w życie ustawy prowadzi się przez 36 miesięcy od dnia wejścia w życie ustawy na podstawie przepisów dotychczasowych.

2. Postępowania w przedmiocie wydania decyzji WZ, dotyczące budynku mieszkalnego albo budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, wszczęte po dniu wejścia w życie ustawy prowadzi się na podstawie przepisów dotychczasowych przez 36 miesięcy od dnia wejścia w życie ustawy.

3. W przypadku decyzji WZ wydanej na podstawie postępowań, o których mowa w ust. 1 i 2, przesłanki odmowy przez organ administracji architektoniczno-budowlanej wydania pozwolenia na budowę lub, w przypadku zgłoszenia, wniesienia sprzeciwu, nie stanowi fakt, iż inwestycja ta nie spełnia wymogów, o których mowa w art. 4.

4. Decyzje WZ dotyczące budynku mieszkalnego albo budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, wydane przed dniem wejścia w życie ustawy, zachowują moc.

5. Postępowania w przedmiocie wydania decyzji WZ, dotyczące elektrowni wiatrowych, wszczęte i niezakończone do dnia wejścia w życie ustawy umarza się.

6. Decyzje WZ dotyczące elektrowni wiatrowych wydane przed dniem wejścia w życie ustawy tracą moc, chyba że przed dniem wejścia w życie ustawy wobec inwestycji nimi objętych wszczęto postępowanie o wydanie pozwolenia na budowę.

7. Utrata mocy decyzji, o których mowa w ust. 6, nie wymaga stwierdzenia ich wygaśnięcia w trybie określonym w art. 162 Kodeksu postępowania administracyjnego.

Art. 15. 1. Studia uwarunkowań i kierunków zagospodarowania przestrzennego gminy oraz plany zagospodarowania przestrzennego województwa uchwalone przed dniem wejścia w życie ustawy zachowują ważność.

2. Plany miejscowe obowiązujące w dniu wejścia w życie ustawy zachowują moc.

3. Jeżeli w planie miejscowym, o którym mowa w ust. 2 lub w ust. 7 pkt 1, przewiduje się lokalizację elektrowni wiatrowej, organ administracji architektoniczno-budowlanej odmawia wydania pozwolenia na budowę, a organ prowadzący postępowanie w sprawie decyzji o środowiskowych uwarunkowaniach odmawia zgody na realizację przedsięwzięcia, jeżeli ta inwestycja nie spełnia wymogów, o których mowa w art. 4.

4. Jeżeli w planie miejscowym, o którym mowa w ust. 2 lub w ust. 7 pkt 1 oraz w ust. 8, przewiduje się lokalizację budynku mieszkalnego albo budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, przesłanki odmowy przez organ administracji architektoniczno-budowlanej wydania pozwolenia na budowę lub, w przypadku zgłoszenia, wniesienia sprzeciwu, nie stanowi fakt, iż inwestycja ta nie spełnia wymogów, o których mowa w art. 4.

APPENDIX1.6

5. W przypadku, o którym mowa w ust. 3, do wniosku o wydanie decyzji o pozwoleniu na budowę elektrowni wiatrowej inwestor dołącza dodatkowo informację wskazującą na spełnienie warunków określonych w art. 4, zawierającą dodatkowo:

1) wskazanie projektowanej wysokości elektrowni wiatrowej;
2) kopię mapy ewidencyjnej obejmującej nieruchomości położone w stosunku do elektrowni wiatrowej w odległości równej i mniejszej niż określona w art. 4;
3) wskazanie aktualnego sposobu zagospodarowania, w tym zabudowy, nieruchomości położonych w stosunku do elektrowni wiatrowej w odległości równej i mniejszej niż określona w art. 4;
4) wypis i wyrys z planu miejscowego obejmującego nieruchomości położone w stosunku do elektrowni wiatrowej w odległości równej i mniejszej niż określona w art. 4;
5) informacje o występowaniu form ochrony przyrody, o których mowa w art. 6 ust. 1 pkt 1–3 i 5 ustawy z dnia 16 kwietnia 2004 r. o ochronie przyrody oraz od leśnych kompleksów promocyjnych, w stosunku do elektrowni wiatrowej w odległości równej lub mniejszej niż określona w art. 4.

6. Do projektów aktów, o których mowa w ust. 1, albo ich zmian, w stosunku do których przed dniem wejścia w życie ustawy dokonano wyłożenia, a w przypadku planu zagospodarowania przestrzennego województwa – przedstawiono projekt planu ministrowi właściwemu do spraw rozwoju regionalnego w celu stwierdzenia jego zgodności z koncepcją przestrzennego zagospodarowania kraju oraz programami rządowymi, stosuje się przepisy dotychczasowe.

7. Do projektów planów miejscowych albo ich zmian oraz inwestycji realizowanych na podstawie ustaleń tych planów, w stosunku do których przed dniem wejścia w życie ustawy:

1) dokonano wyłożenia, stosuje się przepisy dotychczasowe;
2) nie dokonano wyłożenia, stosuje się przepisy ustawy.

8. W ciągu 36 miesięcy od dnia wejścia w życie ustawy dopuszcza się uchwalanie planów miejscowych przewidujących lokalizację budynku mieszkalnego albo budynku o funkcji mieszanej, w skład której wchodzi funkcja mieszkaniowa, na podstawie przepisów dotychczasowych.

9. Przepisów ust. 8 nie stosuje się do planów miejscowych przewidujących lokalizację nowej elektrowni wiatrowej.

10. W przypadku planów miejscowych, o których mowa w ust. 7 pkt 1, przewidujących lokalizację elektrowni wiatrowej, właścicielom oraz użytkownikom wieczystym nieruchomości znajdujących się na obszarze wyznaczonym zgodnie z art. 7 przysługuje prawo zaskarżenia tego planu miejscowego do sądu administracyjnego.

Art. 16. 1. Sprawy wszczęte i niezakończone dotyczące postępowań w sprawie pozwoleń na budowę elektrowni wiatrowych oraz pozwoleń na użytkowanie elektrowni wiatrowych są prowadzone przez organy, które były właściwe do ich prowadzenia przed dniem wejścia w życie niniejszej ustawy.

2. Sprawy wszczęte i niezakończone dotyczące decyzji o środowiskowych uwarunkowaniach elektrowni wiatrowych są prowadzone przez organy, które były właściwe do ich prowadzenia przed dniem wejścia w życie niniejszej ustawy.

Art. 17. Od dnia wejścia w życie ustawy do dnia 31 grudnia 2016 r. podatek od nieruchomości dotyczący elektrowni wiatrowej ustala się i pobiera zgodnie z przepisami obowiązującymi przed dniem wejścia w życie ustawy.

Art. 18. Ustawa wchodzi w życie po upływie 14 dni od dnia ogłoszenia.

Prezydent Rzeczypospolitej Polskiej: *A. Duda*

APPENDIX2

شىنجاڭ ئۇيغۇر ئاپتونوم رايونى تەنتەربىيە ئىدارىسى تەنتەربىيە مەشقى ئىككىنچى چوڭ ئەترىتى

新疆维吾尔自治区体育局体育训练二大队

Xinjiang Equestrian Team of Sport Bureau
No. 37 Santunbei Road, Tianshan District,
Urumqi, Xinjiang 830000, China
Tel: 0991-2562050
Fax: 0991-2562050
Email: 51203169@qq.com

關於新疆風能發電機在畜牧業附近的建設

Regarding the building of wind energy turbines near livestock breeding farms Xinjiang

牲畜養殖場與風力發電機之間的距離必須2000米為止。 原因風力發電機對產生在健康和福祉方面的負面影響。

The required distance between wind turbines to livestock is 2000 meters. This is because of the negative impact that wind turbines have on the health and wellbeing of livestock animals.

新疆馬術運動的官方部門要求風能發電機和馬術訓練中心之間的距離至少2000米。 風能發電機的向外與看不見的效應對動物，騎教練員和馬術中心運行有危險和金融風險的可能。

The official department of Equestrian Sports in Xinjiang requires at least a 2000m distance between a wind energy turbine and an equestrian training center. The outward and unseen effects of wind energy turbines are dangerous and costly to the animals, riding trainers and the running of the equestrian centers.

APPENDIX3.1

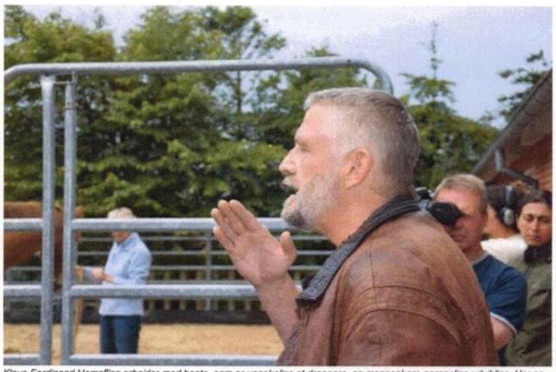
Vindmøller lukker kursuscenter

DEL ARTIKLEN

Print Mail

Akedah International lukket centret på den tidligere Møborg Skole, fordi bølger fra vindmøller gør det umuligt at udføre arbejdet der.

Af Lars Kamstrup, kamp@folkebladetlemvig.dk
Torsdag den 4. august 2016, 08:44



Klaus Ferdinand Hempfling arbejder med heste, som er vanskelige at dressere, og menneskers personlige udvikling. Her er han ia ktion ved åbningen i Møborg for et års tid siden. Arkivfoto: Lars Kamstrup.

MØBORG For et år siden åbnede Klaus Ferdinand Hemfling et kursuscenter for sin virksomhed Akedah International på den tidligere Møborg Skole. Et center, hvor han arbejder med mennesker fra hele verden, og hvor også han bruger sine evner inden for træning af heste. Hestehviskeren, kunne man kalde ham, når man ser ham i aktion med heste, der ikke let lader sig dressere.

Men nu er det allerede slut. Klaus Ferdinand Hemfling sætter kursuscentret til salg, og det vil han informere om på et informationsmøde på den tidligere skole på lørdag den 6. august klokken 10.00. Her vil orientere naboer og andre interesserede om, hvorfor han har taget denne beslutning.

Begrundelsen skal findes i de nye vindmøller, som er sat op tæt på kursuscentret, og som ligger lige ved kommunegrænsen til Holstebro. Disse vindmøller gør, at Klaus Ferdinand Hemfling ikke kan udføre sit arbejde, og han føler sig nødsaget til at skille sig af med stedet.

MEST LÆSTE

- Elmast gik op i røg
- Mistænkelige mænd stak af
- Brød ind i garage
- Taxa blev ramt af kastet frugt
- Bjergbanen får alligevel penge
- Roklubben er den nyeste kandidat
- Bedre medicinering koster på økonomien

TILMELD NYHEDSBREV

Få flere fordele

Fordelsklubben giver dig lokale og unikke oplevelser - læs mere her

email: Tilmeld

SENESTE NYHEDER

Hele landet Lemvig

Anklagemyndigheden anker ikke frifindelser i terrorsag	14:32
Drengene ville nok være på havnen i stedet	14:29
Nu får de deres opfindelse sat på skinner	14:20
To skuespillere får fængselsstraf for overgreb på drenge	14:16
To mænd idømmes fængsel for overgreb	14:06
Kulturstyrelsen bruger 1,2 millioner årligt på Pokémon	14:04
Redaktør: Samsung bevarer tronen trods brandskandale	14:03
PET anmelder Jakob Scharf for at bryde tavshedspligt	13:52

RSS feed

FORSIDEN NETOP NU

Løse sæder og skideballe af chaufføren: Mødre raser mod special-kørslen

LEMVIG Fem mødre står nu frem for at fortælle om massive problemer med den nye kommunale special-kørsel. Læs mere

Varmeværk fastholder lav varmepris

APPENDIX3.2

været det, havde jeg aldrig købt den. Jeg vidste, at vindmøller ikke er foreneligt med det arbejde, der udføres på vort center,« siger Klaus Ferdinand Hemfling.

Det er ikke den støj, man kan høre med den normale hørelse, som er problemet. Det er de bølger, som vindmøllerne sætter i gang.

»Der kommer bølger fra vindmøller akkurat som fra jordskælv. Det er den samme mekanisme, der for eksempel gjorde, at elefanterne forsvandt fra Phuket i Thailand tre dage før, katastrofen skete. Disse bølger er ikke videnskabeligt bevist, men undersøgelser i for eksempel Canada viser, at de er der. Og som eksempel kan nævnes, at de apparater, der skal registrere jordskælv ligger mange kilometer væk fra vindmøller netop på grund af denne påvirkning.«

Klaus Ferdinand Hemfling fortæller, at det påvirker de mennesker, der er på kursuscentret i Møborg. De har dårlige oplevelser, sover dårligt med mere. Og hestene er påvirket. Noget han aldrig har været ude for på andre af organisationens centre.

»Jeg er selv påvirket. Jeg kan ikke arbejde. Det startede, da møllerne begyndte at køre først på året. Jeg må derfor tage konsekvensen af det og lukke ned og flytte vore aktiviteter andre steder hen. Det er ærgerligt, da vi netop har fået bygget et flot center op, og jeg elsker Møborg-området. Vi er blevet godt behandlet af naboer og offentlige myndigheder. Jeg er ikke den type, der vil protestere og gå med bannere, fordi møllerne generer mig. Jeg har holdt møder med personerne fra vindmølle-firmaet og de to kommuner, og de har været positive. Jeg er helt klar over, at møllerne overholder alle de regler, der er i Danmark. Men det er fordi, man ikke anerkender generne af disse bølger,« siger Akedah-stifteren.

Han siger, at afstandskravene er alt for små, fordi møllerne skal meget længere væk, hvis man skal undgå at blive forstyrret af disse bølger, som møllerne sætter i gang.

»Det vil man erfare i Danmrk, og det vil være fint, hvis man rydder landjorden for dem. Hvis jeg ikke har solgt om 10 år, og møllerne er væk, så kommer jeg tilbage. Jeg er glad for Møborg-området.«

Men nu lukker-han altså ned i Møborg og sælger.

»Men jeg vil ikke sælge til familier med børn. Jeg vil fortælle om disse bølger. Derfor er det en erhvervsvirksomhed, jeg vil henvende mig til. Der skal ikke bo familier i en ejendom, hvor jeg selv har været ude for disse problemer. De skal ikke holdes skjult, fordi vi skal sælge,« siger han fra Akedahs hovedsæde i Snedsted på Thy.

Synes godt om 118 personer synes godt om dette.

3 kommentarer Sortér efter Ældste

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Ib Fyhring · Avis kørelse hos Selvstændig
Bodil Pedersen
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Nadia Faurby Olesen · Kranio Sakral Terapeut og Healer hos Selvstændig hjemme
Manuela Faurby Olesen, har du læst det her?
Synes godt om · Svar · 4. august 2016 12:41

Manuela Faurby Olesen · Sygeplejerske hos Ramme Rehab
Ja nu har jeg.
Syrles godt om · Svar · 1 · 4. august 2016 12:53

Birgit Sell Sørensen · Træner hos Samspils træning.
Skal vi tá ud og møde ham?
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Drengene ville nok være på havnen i stedet
LEMVIG Der bliver skruet på motorer og maskiner i kælderen under Lemvig Ungdomsgård, hvor crossafdelingen frygter hvad der kan ske, hvis besparelse på ... Læs mere

Nu får de deres opfindelse sat på skinner
STRUER »Det kan blive stort det her,« mener

APPENDIX4.1

Published on *East County Magazine* (http://www.eastcountymagazine.org)

DO WIND TURBINES HARM ANIMALS?

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May 2012 Articles

wind turbines wind farms dirty energy wind turbines animals wind turbines wildlife stray voltage infrasound

By Mia Myklebust and Miriam Raftery

May 10, 2012 (San Diego's East County) – With an increasing number of industrial-scale wind turbines around the world, numerous reports are surfacing to suggest that noise, infrasound and stray voltage (dirty energy) may be harmful to livestock and wildlife.

While evidence is largely anecdotal, incidences of mass die-offs of farm animals, chickens laying soft-shelled eggs, high animal miscarriage rates and disappearánce of wildlife near turbines provide pause for reflection. These and other incidents suggest a need for scientific study to determine safety before additional wind energy facilities are erected across the U.S., including several proposed in San Diego's East County.

Although wind turbines have been growing in popularity as an energy alternative in the 21 st century, there has been little to no testing done on the effects that these towering turbines could have on animals or for that matter, humans in the vicinity. We require testing of chemicals to assure safety before they may be used in the environment. Why is similarly rigorous testing not required to date for wind turbines?

This is concerning particularly in East County, which has among the highest number of horses per capita in the U.S. along with other livestock. In addition the region is home to endangered Peninsular Big Horn sheep, rare birds such as the tri-color blackbird, eagles and hawks, mountain lions and other wildlife. Even pets such as dogs and cats potentially could be impacted.

Federal wildlife authorities voice concern over wind impacts on wildlife

There are currently no noise standards for wildlife in the U.S. However the U.S. Fish & Wildlife Service, in a document titled The Effects of Noise on Wildlife, concludes that "although there are few studies specifically focused on the noise effects of wind energy facilities on birds, bats and other wildlife, scientific evidence regarding the effects of other noise sources is widely documented."

Those impacts include both audible noise and low-frequency infrasound which turbines generate. "It is important to take precautionary measures to ensure that noise impacts at wind facility are thoroughly investigated prior to development," the USFWS determined.

APPENDIX4.2

Declines in some bird species have occurred at noise thresholds as low as 35 decibals (dba), the USFWS notes. Noise levels of 35 to 43 dba have been measured up to a mile from turbines. Closer in, within 300 feet, sound levels of 50 dba have been recorded. Noise can interfere with communications among birds, having an impact "ultimately on avian health and survival," according to the USFWS report.

Mass animal die-offs

In an article titled Are Wind Turbines Killing Innocent Goats? Discovery Magazine reported that a Taiwanese farmer blames the death of 400 goats on a nearby wind facility. His claim is backed up by a local livestock inspector who said unusual sounds can impact animals' appetite, growth and sleep. The farmer has stated that the goats had been unable to sleep and began losing weight prior to their deaths.

- In Wisconsin, a farmer who tells his story on YouTube describes losing 19 cattle that died or had to be put down because they were "pretty much lifeless." In addition, 30 calves have died. The farm is within a mile of a wind facility. One cow removed from the site and moved elsewhere later recovered, the farmer stated.

Reproductive problems

An Ontario, Canada goat farmer reported that all 20 of his nanny goats miscarried or had kids that died within hours of birth.

Dr. Nina Pierpont, author of Wind Turbine Syndrome, interviewed a horse breeder who lost six of eight babies after wind turbines were erected nearby his breeding mares. Some aborted early, others had no milk and others didn't conceive.

"I've been in the horse business for 45 years," the rancher said. "I don't know whether there's dirty electricity in the ground, I don't if they keep them from sleeping…but there's something."

If turbines are, in fact, causing miscarriages and other reproductive problems in large animals, what could this mean for the health of pregnant women and women of child-bearing age living in close proximity to the turbines?

The public has no answers, because governments have not required any scientific testing to prove that turbines are safe for humans or animals, despite the proliferation of massive wind projects approved or in the pipeline.

Additional animal issues in wind turbine areas

Chickens near wind farms have been known to lay shell-less or soft-shelled eggs resulting in deaths of chickens.

Dr. Nina Pierpont at Johns Hopkin University School of Medicine has concluded that Wind Turbine Syndrome occurs in people as well as in animals. "During my research interviews I collected anecdotal information on animal problems. I heard about moles, deer, dogs, horses, ponies, alpacas, goats, seals, sea eagles (Norway), killdeer, and frogs—all of whom disappeared, behaved abnormally, and/or had observed reproductive failure," she has written.

APPENDIX4.3

It is widely known that bird kills are common when birds collide with whirling turbine blades. Most notoriously, the Altamont wind farm in California has killed thousands of golden eagles, as well as many other birds.

The impacts for bats, however, are even worse. Mass bat die-offs can occur even when bats don't strike blades, because their lungs explode from the air pressure changes, an article in Current Biology reported in 2008.

In some portions of Wisconsin, Canada and other areas, residents have reported disappearance of wildlife ranging from hummingbirds to crickets to nesting swallows after wind turbines came into the area. Some pet owners have also reported unusual behavior in dogs, such as a reluctance to go outside when turbines are spinning.

Noise impacts on marine mammals

In Germany, a dozen dead porpoises washed ashore near the site of a newly completed wind farm and authorities did not rule out the wind facility as potential causes. Some have suggested that the beaching of 130 dolphins at Cape Cod may be related to wind turbine facilities nearby. At high levels, sound from military sonar has been shown to be fatal to marine mammals, the National Resources Defense Council has reported.

What are the lowest sound thresholds that are safe for whales, porpoises and other marine mammals? More study appears necessary.

Stray voltage

Animals can also be impacted negatively by stray voltage, also known as dirty electricity. Cows living near power lines, for example, have experienced reduced milk production and even been observed "dancing" in fields due to electricity in the ground, according to scientific research presented by experts at the International Conference on Production Diseases in Farm Animals at Michigan State University.

Magda Havas, PhD, has published a provocative article titled "What do Dancing Cows and Zapped Dogs Have in Common?" Havas reports on stray voltage, or ground current, in Toronto, Canada that killed a dog and zapped a child. Cattle have been videotaped "dancing" or lifting hooves repetitively from being shocked by electrical voltage in the ground, Havas reveals.

High ground currents from stray voltage have been measured near multiple wind facilities, including Palm Springs and Campo, California. The latter has had ground currents measured at 1,000 times normal in the Manzanita Indians' tribal hall and church near a wind facility on a neighboring reservation, according to measurements taken by Dr. Samuel Milham, author of Dirty Energy.

Cumulative observations in some geographic areas

One sheep farmer in Waterloo, Australia had a three-fold spike in birth defects since the turbines started operating. This year, lambs have been born with no ears, three legs and hoofs turned backwards, the Australian

APPENDIX4.4

newspaper reported. While it's difficult to know the cause for a handful of birth defects, the fact that they occurred in the same area where chickens have begun laying yolkless eggs and many humans have complained of health problems increases concerns.

A growing number of geographic areas now report animal symptoms overlapping human health complaints after wind turbines are built. Is it all just coincidence?

Conclusion

Mounting anecdotal evidence suggests a need for caution before building wind turbines in areas near wildlife, livestock, and people. While it's too soon to conclude that turbines have caused the various health problems and fatalities in animals near industrial wind facilities, it is also dangerous to assume that wind turbines are safe for animals or humans living in close proximity.

To read about additional incidents of unusual animal behavior and health impacts observed near wind turbines, visit http://www.windturbinesyndrome.com/category/what-effects-do-wind-turbines-have-on-domestic-animals-wildlife/?var=aa.

Source URL (modified on 08/18/2012 - 21:54): http://www.eastcountymagazine.org/do-wind-turbines-harm-animals

APPENDIX5.1

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HOME WIND TURBINE SYNDROME EVE'S BREAST THE GREAT FORGETTING CONTACT

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Horses get Wind Turbine Syndrome (Portugal)

May 13, 2013

Editor's note: Horses, as well as humans, suffer from being in close proximity to wind turbines, strongly suggests a study performed last year at the School of Veterinary Medicine, Technical University, Lisbon, Portugal. The study was written up as a Master's thesis, titled "Acquired flexural deformity of the distal interphalangic joint in foals."

> On this stud farm, the owner has been breeding normal and physically sound horses since 2000. There were no changes in diet, exercise or any other significant alteration in management. Until in 2008, wind turbines were installed adjacent to the property and grazing paddocks. Since this date, a good number of foals and yearlings have developed deformities.
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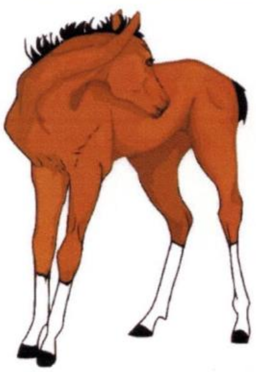
> The subjects of the study were: 11 Lusitano horses. Age between 0 and 48 months old. 6 males and 5 females . 9 were born at the stud farm, 2 were acquired from a different breeder.



The M.A. thesis was presaged in a **conference paper** by Professor Mariana Alves-Pereira et al. several years ago, and summarized as follows.

APPENDIX5.2

In 2007, at the 2nd International Conference on Wind Turbine (WT) Noise, held in Lyon, France, low frequency noise (<500 Hz, LFN)-induced pathology, consistent with vibroacoustic disease (VAD), was shown to be emerging in the R. Family, exposed to residential LFN generated by 4 WT installed in close proximity (300-700 m) to their home. Herein, a follow-up is provided.

The wife and 2 children no longer reside within that home. Mr. R., however, must remain to care for the thoroughbred Lusitanian horses and bulls that he trains and breeds for bullfights.

In addition to the continued deterioration of Mr. R's health and well-being, his financial situation is aggravated by the condition now appearing in his horses during the first year of life. Between 2000 and 2006, 13 healthy thoroughbred Lusitanian horses were born and raised on Mr. R's property. All horses (N=4) born or raised after 2007 developed asymmetric flexural limb deformities. WT began operations in November 2006. No other changes (constructions, industries, etc) were introduced into the area during this time.

Tissue analyses of the defected tendons were performed and revealed the classical features of LFN-induced biological responses: thickening of blood vessel walls due to proliferation of collagen in the absence of an inflammatory process.

In a personal communication, Alves-Pereira underscores, "The observation in these horses of abnormal growth of collagen in the absence of an inflammatory process is in conformity with the same observations found in low frequency noise (LFN)-exposed rats, and in vibroacoustic disease patients who are employed in LFN-rich environments."

The following text is taken from **here**, with appreciation.

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Abstract:

Since 2008, a high prevalence of front limb acquired flexural deformities was observed in a Lusitano stud farm. This work aims to evaluate this problem by reporting the results from tissue alterations in the affected animals as well as environmental conditions and management changes, which could have led to this observation. A total of eleven affected animals were studied. In these, a complete physical and orthopaedic examination were performed specifically the determination of the angle between the dorsal hoof wall and the floor. Radiographic examination, CT imaging, determination of the thickness of the cortical bone of the third metacarpian and histopathology of some tissues collected in biopsy and necropsy were done in a subset of affected foals.

All the animals had been supplemented with balanced commercial diet for equine. To investigate a possible genetic cause, two foals from distinct bloodlines were brought to the stud. These also developed the deformities after 6 months. Two of the affected foals were placed in a pasture away from the initial one and two others were admitted at the Faculty of Veterinary Medicine of Lisbon. In those animals, except for one that had to be euthanized for humane reasons, an improvement was observed on their
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APPENDIX5.3

condition, with partial recovery of the deformity. Histopathology was performed from (i) the tendon obtained by surgical desmotomy in one foal, (ii) tendon biopsies were performed in three foals and (iii) from the tissue of one foal during necropsy. Histologically the most significant alterations were the dissociation of myofibrils of the smooth muscle. This was predominantly seen in the small intestine but also in the walls of small capillary vessels, including those of the tendon vasculature. The flexural deformities have a complex and multifactorial etiopathogeny. They occur due to uncoupling of the longitudinal development of the bone and its adjacent soft tissues, but also from shortening of the tendon-muscle unit in response to pain. In the case series presented here, there was no obvious cause for the development of this problem, therefore we hypothesised that unusual environmental conditions might have played an important role in the development of this condition, especially those introduced in recent years.

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The following is the summary of a case study of a group of Lusitano horses that have been monitoried over 4 years which were the subject of a masters thesis at the Faculty of Veterinary Medicine, Technical University, Lisbon, completed in 2012.

The study was performed by Teresa Margarida Pereira Costa e Curto, ADVISOR: Dr. Maria da Conceição da Cunha and Vasconcelos Peleteiro CO-ADVISOR: Dr. Maria Luisa Jorge Mendes.

The study reports the findings from a stud where 11 foals developed flexural deformities of the front limbs, after they were born. (Acquired flexural deformity of the distal interphalangeal joint.)

The above image shows the same foal at 3 and 6 months of age
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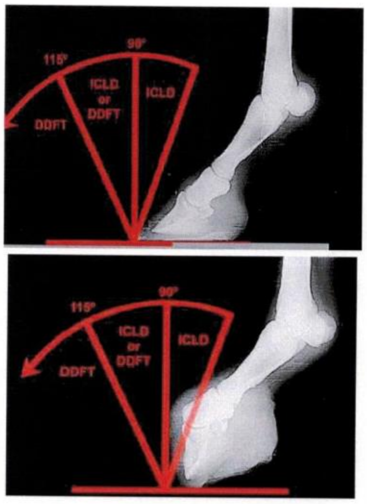
APPENDIX5.4

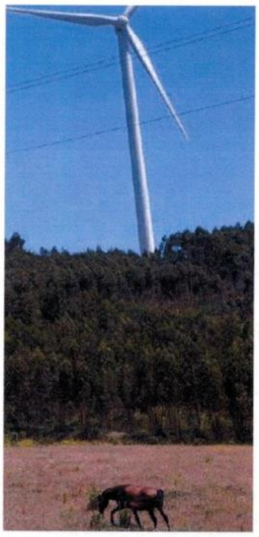
A foal was bought from another breeder to exclude a possible genetic link to this problem. He came to the farm at 15 days old and like the others, developed a flexural deformity.



Radiological examination of front limbs

The following tests were used for the study: • Anamnesis • Clinical examination • Goniometry • Ultrasound and x-ray • Measurement of cortical bone • CT • Desmotomy of the check ligament • Histopathology • Sound measurements • Measurements of ground vibration

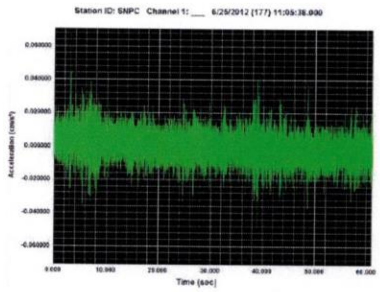
APPENDIX5.5



Proximity of horses to wind turbines

Aerial view of farm proximity to wind turbines

APPENDIX5.6



Measurements of ground vibration were made at different distances from the wind turbines, with the same equipment that is used to detect seismic vibrations (earthquakes). The results of these measurements, showed ground vibration at different frequencies. Research has shown that vibration effects bone metabolism.

Cellular Mechanotransduction is the mechanism by which cells convert mechanical signals into biochemical responses. Based on the mechanical effects on cells it was proposed in this research project that the ground vibrations were responsible for a increased bone growth which was not accompanied by the muscle-tendon unit growth leading to the development of these flexural deformities.

The above research project was based solely on this case study. Therefore, further research is necessary in order to validate these preliminary findings and hypothesis. Regarding the sound that the wind turbines produce, measurements were taken and studies have demonstrated some cellular damage is caused by low frequency noise.

The full thesis can be downloaded **here** in Portuguese.

7 Comments »

Comment by Frank Haggerty on 05/13/2013 at 8:25 pm

APPENDIX5.7

Jon Boone of Maryland produced a documentary "Life Under a Windplant". In the classic documentary it shows how the wild animals had left the area around the wind turbines in Meyersdale, Pa.

This documentary should be mandatory in the public school systems in the United States.

https://www.wind-watch.org/video-meyersdale.php

Comment by Yuki Tsuruta Oike on 05/13/2013 at 8:36 pm

I would like to thank Dr.Alves-Pereira.

I wrote the following report in 2010. I need more information!

http://www.windturbinesyndrome.com/2010/dairy-cattle-suffer-from-wind-turbine-syndrome-japan/?var=wts

Comment by Jackie on 05/13/2013 at 9:40 pm

This breaks my heart! Subjecting turbines to humans is bad enough, at least we are capable of fighting.

Comment by Kaz on 05/13/2013 at 11:03 pm

Oh, my God.

I'm feeling physically ill.

How many studies will be done, how many people, animals and environments will suffer before the world wakes up, gets mad and does something about this?

Human victims are still called liars…or worse, emotionally unstable…victims of a 'nocebo' effect…if they complain of illness due to ILFN. And the world accepts the industry's diagnoses and ALLOWS the suffering to continue.

Bird and bat fatalities are written off, true numbers hidden, the proven deaths marginalized as acceptable 'take'…for the oft-touted 'greater good' that wind turbines are supposed to provide–but which they can't and don't. But citizens have bought the stories, accepted the industry lies…and are ALLOWING needless, countless deaths.

Farm animals miscarry, lose their appetites, suffer stress…but SURELY that must be because of some OTHER factor. It doesn't matter that they were happy and productive (and reproductive) prior to living within the sound-shed of turbine installantions. Surely, the farmer has introduced some toxin, changed some feed, neglected some precautionary measures…and the new anomalies are HIS fault! And guess what? People buy into those theories because it's not happening to them, or to their animals…and because it's easier than fixing this damned colossal, GLOBAL mistake…so they ALLOW animals to suffer, farmers to lose their livelihoods…

APPENDIX5.8

Wildlife scatters. Yes, they may return briefly but they don't stay. They live in and require a natural environment where they depend on the full use of their extraordinary senses…acute hearing being one of the most vital. A deer will not browse if it suspects danger. It stops, stands still, listens, sniffs the air, watches for unnatural movement. Only when its senses tell it that all is well will it drop its head to eat –and even then, for only a few moments before stopping to listen, again. The multi-level sounds and vibrations from massive turbines tear the air to shreds and effectively remove the ability to gain the relaxed state in which a deer can browse. Rather than starve, it will move on. But the wind industry will take a photo of a rabbit under a turbine, or a cow under a turbine, or a bird gliding gracefully above a turbine and say "See? You guys are wrong. You're fanatics. You're trying to scare people. Animals LOVE these things!" And because they speak louder (money makes a great megaphone) we ALLOW the industry to continue to wreak havoc on our native fauna.

Look at these beautiful, amazing creatures which were the focus of this study/thesis. Is there a more majestic, noble or strong animal? They carry us, pull us, work our forests and plow our fields. They provide us with comfort and companionship and give, give, give until their hearts give out. But what have we done? What are we doing? What are we ALLOWING?

LOOK at what we're allowing. Where is our shame, our outrage, our ACTION?

This makes me sick.

Kaz

Comment by Itasca Small on 05/14/2013 at 6:02 am

Where is the moral outrage? Who answers the Calls-to-Action as this EVIL continues unabated? For all who answer, we need more! The humans and animals of Earth need more aware humans to rise and answer the Call!

Where are the courageous? Whatever our number, it is not enough! We are still ridiculed and demonized by the Evil among us who keep right-on: destroying vegetation, destroying the land, destroying Earth and Life, wherever they are welcomed by governments to build their spinning head, toxic noise polluting, monstrostties of steel, concrete, Rare Earth Elements, and flashing lights.

Small victories occur with God's help, i.e., my very small, remote community staving-off the Goliath, RES Americas, in its intent to site Industrial Wind Turbines (IWTs) as close as one-half-mile from the outer walls of our residences. But, Iberdrola's existing monsters ~10.25 miles from our neighbor nearest to them, continue to spin and cause increasing adverse health effects in the humans and animals at least as far as 12.5 miles away. Because our local county government still refuses to protect us from the pernicious scourge. Why? We have failed to overcome the indoctrination and educate our fellow-citizens in OUR OWN BACKYARD!!!

Other victories are being won, and I praise the LORD for each of them. BUT, IT IS NOT ENOUGH!!!

Right now, Dr. Sarah Laurie is facing the threat of professional censure in Australia for allegedly CAUSING WIND TURBINE SYNDROME IN HUMANS BY TELLING US WE COULD GET SICK FROM INDUSTRIAL WIND TURBINES SITED TOO CLOSE TO OUR HOMES.

APPENDIX5.9

A cowardly, anonymous complaint charges her with conducting unauthorized research on human subjects and thereby creating a "nocebo" effect in the people who hear the results of her legitimate, scientific investigations of the harm occurring from IWTs.

This nonsensical desperate charge claims we get sick because "anecdotal" claims are communicated to us!!! Never mind that MANY victims of wind turbine syndrome (WTS) have no knowledge of any adverse health claims when the symptoms begin and get worse – they are seriously making this ridiculous charge against Dr. Laurie!

The nocebo effect is actually the "pseudo-scientific" foundation of their attack. Basically, they claim that if one hears that wind turbines might be harmful, he will develop the alleged symptoms through no fault of the turbines – or of the developers! In the Year 2013 AD, given all the facts and evidence readily available to anyone choosing to seek them out, there is absolutely no scientific basis for this ridiculous LIE. (I DARE CALL IT EVIL!!!)

The wind industry is bringing "all guns" to bear on this courageous doctor who is dedicating her professional life to investigating, writing, and speaking-out; to warn her own Nation and the world, of the truth about IWTs and their destructive effects on human life.

The most outrageously egregious fact in this "witch hunt" by wind developer groupies in collaboration with the developers, is that Australia's "professional" National Health and Medical Research Council (NHMRC) and two other governmental groups are taking the charges seriously. The NHMRC claims it doesn't accept public comments on charges against individuals; an effective way to ward-off unwanted testimonials in support of a doctor who is in their sights. Other methods must be used to support Dr. Laurie. But what is to be done?

The Waubra Foundation's board of directors is standing behind Dr. Laurie; they submitted the initial response to the complaint on her behalf, calling for proper, public investigation of the charges and of WTS. But, the influence of the wind industry and pseudo-scientific "witch doctors" (e.g., Professor of Public Health, Simon Chapman, a vigorous advocate for the nocebo effect) in Australia's professional and media circles is strong. Dr. Laurie faces an uphill battle, and the board's statement was the first volley in her defense.

What can Warriors Against Wind Energy do to help? I don't know the definitive answer, but I can suggest that the Australian Government and Media be made to feel the intensity of phone calls, e-mails, regular mail, blog exposure, etc., from WTS sufferers and knowledgeable professionals from around the globe.

And, Warriors Against Wind Energy in Australia could redouble their efforts at this critical time, to reach the Australian citizenry, to stir the passions of righteous indignation against the lying anonymous sycophants and the wind industry developers seeking to destroy Dr. Laurie solely in order to rid themselves of a very effective force fighting against them. If she is not defended vigorously and loudly by those who know the truth, she will be figuratively sacrificed to the false, Wind Industry gods. Australian's could facilitate the worldwide effort by providing information on whom to contact. But, what do we say?

Beating the drums in the name of human victims is not working. We need to concentrate on the animals! The answer to claims of the nocebo effect is in the animal kingdom. The world is too slow to accept the truth about human health effects because the indoctrination claiming wind energy to be Earth's Savior against alleged man-made global warming has been unbelievably successful.

Ironic that Man stands accused of destroying Earth's Climate with his technology on the one hand, while on the other he is convinced that inefficient and toxic 19th Century technologies can save it; if he will just sacrifice all of the modern human advancement dependent upon… Technology!

This current distressing article about foal horse WTS victims graphically exposes the long-known fact that IWTs destroy animal life even more tragically than human life. THEY, LIKE HUMAN CHILDREN, CANNOT COMPREHEND WHAT IS HAPPENING TO THEM!!! Even so, they DO perceive the cause! And, they escape when they are able!!! The Ignorant and the Evil point to the rabbits and the cows photographed resting beneath IWTs, but they fail to realize that these animals DON'T LOVE THE MONSTERS. They perceive the absence of infrasound and low frequency at the base of their torturer!

There are diagrams that show the angle at which sound waves propagate from the spinning heads of IWTs; they are projected outward in a cone-shaped geometry away from the tower! I believe the additional ILFN that propagates through the tower into the ground and outward from there, is concentrated in the equivalent of standing waves that are amplified into much stronger ILFN within the semi-circular, mostly hollow towers. Under and next to the IWT is the safest place to be if you're an animal and can't escape any other way.

The wind industry and others can successfully argue nocebo to the gullible, the ignorant and the willfully blind humans, because some human beings have reportedly evidenced a nocebo effect in certain instances unrelated to IWTs. But, to attribute WTS to such a notion is completely unfounded. So, how to prove this fact?

The answer, again, is in the Animal Kingdom. What reasonably logical and rational human being is going to believe, let alone posit, that the foal horses in this infuriating article GAVE THEMSELVES "Acquired flexural deformity of the distal interphalangic joint…" ? No one can say these foals CRIPPLED THEMSELVES with Vibroacoustic Disease!

Three years ago, my neighbors and I were awakened to the reality of the insidious wind energy crime against Life on Earth. One of the first articles I read online was about the Taiwanese Goat Farm at which 400 goats had died from the effects of IWTs – I know the articles say it's yet to be proven, but, I DON'T NEED FURTHER PROOF! Common sense is life-protective.

Having bred, raised, and shown world-class Nubian Dairy Goats in my youth, I know goats, and I've heard enough about goats in Illinois, alpaca's in Wisconsin, and numerous other animals relative to IWTs, to know that the turbines killed those Taiwanese goats. Goats happen to be very sensitive to any sudden, loud, audible and low-frequency noise. Spontaneous abortion occurs readily in goats subjected to noise. Goats could be WTS "bellwethers," if it were humane to use them as test subjects. Here is an article on the Taiwanese goats: **http://news.bbc.co.uk/2/hi/asia-pacific/8060969.stm**; and, an excellent one addressing them and a variety of other animals:
http://eastcountymagazine.org/node/9615; May, 2012. More articles are available on the WTS Site and elsewhere online.

I also read Ivan Buxton's haunting 2006 paper, "Low Frequency Noise and Infrasound (Some possible causes and effects upon land-based animals and freshwater creatures)," early-on in my IWT Nightmare. His descriptions of the horrible effects of ILFN, were enough to convince me – and I have never looked-back – that IWTs have NO PLACE ANYWHERE ON EARTH!!! [You can find references to Buxton's paper in the windturbinesyndrome.com Archives, and at this site: **https://www.wind-watch.org/documents/low-frequency-noise-and-infrasound/**]

APPENDIX5.11

The point being, the terrible toll on the Animal Kingdom cannot be explained-away by nocebo. Animals are not sickened or deformed because other animals – or human beings – tell them tales of deformity, sickness and death to Their Kind living near wind turbines!

Hence, I believe we must shine a brighter light on these victims of WTS. Medical professionals know that if a treatment protocol works on animals it is potentially viable for humans, because there is no possibility of placebo effect. Likewise, rational, intelligent, logical professionals MUST be able to see that nocebo cannot occur in animals. So, if they see that animals are suffering and dying, God may remove the scales from their eyes, and they may see the truth about IWTs.

In just the two-and-a-half years since Fellow-Warriors graciously gave me my Dell computer so I could more effectively fight this War, I have "bookmarked" 293 websites or articles on IWTs and all of their adverse effects. And, that doesn't even begin to count all of the articles on the WTS Site, and on many others.

It is not enough! Hundreds of articles telling the truth about Industrial Wind Turbines and Wind Energy overall, are NOT ENOUGH! We don't have Forever to win this War: to save existing victims, and spare potential victims.

We have to start thinking – and ACTING – "outside the box!"

Itasca Small
Wind Turbine Syndrome Refugee,
Navajo County, Arizona, U.S.A

Comment by Yuki Tsuruta Oike on 05/14/2013 at 8:55 pm

Dear Calvin,

Could you correct my comment from "Dr.Alves-Preira" to "Portuguese researchers" ?

By the way I have had a problem to send emails to your address directly.

Cheers,

Yuki

Comment by Itasca Small on 05/15/2013 at 2:36 am

I'm glad Yuki added this comment. I missed her link last night to the article she submitted in 2010. Having just visited that page, I am further incensed by the Global Carnage being perpetrated by the 21st Century descendants of Grand Inquisitor Tomas de Torquemada and the Marquis de Sade.

Evil knows only one father.

Itasca

The comments are closed.

APPENDIX6.1

Natalia Kurek
Vievej 24
8832 Skals

AGAINST WINDMILLS

My name is Natalia Kurek and I am a worker in Viegaard Stutteri Aps. I am an educated veterinarian. I would like to express my objection on building windmills in our neighborhood. There are many disadvantages which maybe you can consider while taking a stand in this case.

The work with horses is very specific kind of work. It requires a lot of patience, attention, sensitivity and concentration. Also horses are very specific kind of animals due to their reaction to stress and danger which is escape as far as possible from source of threats. That is why building of windmills in our neighborhood can make this work more dangerous and create more opportunities of life-threatening accidents.

This is a common knowledge that wind turbines are a source of noise, infrasound, sun reflections, shadows, electromagnetic radiation and vibrations. A lot of studies conducted by scientists all over the world come with conclusions about bad influence on human and animal health. This kind of impact is usually long-term effect and can be noticed a long time after beginning of exposure. A work by doctor Teresa Margarida Costa Pereira e Curto from Libons Faculty of Veterinary Medicine titled "Acquired flexural deformation of the distal interphalangeal joint in foals" is about possible influence of vibrations from the ground made by windmills that can caused joints deformation and incorrect angulations of foals legs. Some level of vibration can lead to molecular changes in growing tendons which length becomes not relate to length of bones and that can cause joint deformation.

There are also disadvantages delivered from increased level of stress. Mares which expect foals are usually in spring/summer time at paddocks which are in near possible location of wind turbines. High level of stress and noise risks of abortion, lack of acceptation of newborn foal and milk production disorders. Horses reactions to danger (noise, shadows) can lead to many accidents such as wounds, bone fractures, contusions which can exclude horse from sport career or sale and even end with decision of euthanasia.

Horses running in panic can cause also many accidents involving humans and their increased level of stress will make my and other people work more dangerous and unpredictible.

Kindly please to consider my opinion during making an official statement.

Sincerely,

Natalia Kurek

Veterinarian

Natalia Kurek

APPENDIX6.2

APPENDIX6.3

Til Viborg Kommune

Låstrup Vindmølle

Jeg er uddannet rideinstruktør under Dansk Rideforbund Instruktør forening. Har repræsenteret Danmark på landsholdet gennem flere år og har bl.a. vundet verdens mesterskabet for hingste i springing.

Jeg har ansvaret for en del heste på Viegaard Stutteri og ligeledes mange rytter fra flere lande.

Jeg vil gerne spørge kommunen hvem har ansvaret for heste og rytters sikkerhed, nar kommunen på forhånd ved, for man bygger vindmølle park, at dette ikke kan forenes med opdrœt af heste, trœning af heste til sport og heller ikke konkurrence da disse skal vare på lige vilkår.

Jeg håber på vi lever i et forholdsvis sikkert land, hvor man tager højde for dyrevelfœr og sikkerhed for såvel heste som rytter.

Jeg ved også at en flok heste på marken kan blive grebet af panik og derefter tager flugten da det er deres natur. Dette kan blive en katastrofe i trafikken. Der vil altid vare mange heste pa viegaard da det er Danmarks storste varmblods stutteri og opstartet for mere en 30 år siden. Så risikoen er større her end andre steder.

Bemœrk at i Portugal har føllene tœt på vindmøller vœret misdannet på viegård bliver ca. født 100 føl per år.

Hvordan kan kommunen lave en fœlde for heste og ryttere? Så endnu engang hvem vil tage ansvaret?

Der er allerede en lokalplan for ridestadium, og jeg er lige nu i Kina hvor vi holder møde om opbygning af stadium, hvilket vil vœre til stor gavn for lokalområdet, da det bringer købekraft til i stor målestok, med 400 heste, rytter, familie, sponsore, hesteejere, tilskurer o.m. fra mere en 20 lande.

Venligst besvar mine sporgsmal, tak
Venlig hilsen
Berider Soren Knudsen
Vievej 4, 8832 Skals

APPENDIX6.4.1

To whom it may concern,

I'm Jacqueline Lai, I'm a 25 year old professional Equestrian athlete from Hong Kong.

I have been residing in Viegaard Sutteri, Skals since 2010 for the purpose of my career as an equestrian. Here, on top of top level training from John Byrialsen, my horses and I benefit from high level facility –stables, indoor and outdoor riding arenas, paddocks- but most importantly a spacious, peaceful and quiet environment is what makes this place ideal for me. Horse welfare is a top priority when I choose where to base, for the love of my horses as well as it being a factor in top performance for sport.

Since 2014 I have been employed at VS as a rider, trainer and client communicator; VS' business runs on the welfare of the horses; sales horses and young horses, breeding mares, foals alike. Our primary business is sales of horses to both professional and amateur people, where the usual practice for sales of riding horses involves an interested client coming to see and sit on the horse to test the ability, the rideability and the nature- learning if the horse is quiet and calm, sensitive or tensed, brave, afraid or unfocused, can be ridden in different areas.

The Lastrup windmill project will have a very negative impact on my sport horses. I myself have 4 horses privately at VS, whom I pay a monthly stabling fee for. Two of these horses are at the level of high-level sport, and two are younger horses in development for sport and sales. My horses are very dear to myself and are vital for me to carry on representing Hong Kong to championship level competitions such as the Asian Games, World Equestrian Games and Olympic Games, but they also hold a very high value in financial terms. The equestrian sport is one of the most expensive sports there is, and risking devaluing my horses due to windmills in the area will not be justifiable.

The presence of windmills will negatively affect the development of VS' horses. A good sport horse is different in the eyes of different people/ways of riding, however they all carry a number of common traits that is scope (capacity, or the ability to jump high and wide), courage, sensitivity, sharpness. This may illustrate how the typical sport horse is different from say the Norwegian fjord horse or the riding school pony, who are usually brave, less sensitive and less reactive to noises, movements and unpredictable things, they also cost a fraction of the price a sport horse on the market. With these traits, sport horses are vulnerable to spooky surroundings. A windmill in the nearby premise will quickly affect the horses' sense of trust; cause them to develop bad habits such as spooking, running away and taking off. If you were a horseman, you would also understand what a task it is it is to regain a horse's trust, or to reeducate a horse with a bad experience, sometimes there is no way back. Alongside the cause of loss of the horses' value, the windmills also pose danger to our riders such as myself, my colleagues and our clients.

The presence of windmills will not only affect VS' clients' safety and chance to have a good experience, there would also be a concern in appeal of VS and the surrounding area as a relaxing getaway. We have a number of clients who enjoy to visit VS long and short term to relax, train, and sometimes buy a horse. With a constant spinning object in the near distance causing distracting shadows and unremitting sound, this will undoubtedly cause a big loss for the business. Meanwhile VS as well as their clients will have to consider insurance on their million dollar horses, though even this cannot make up the loss. With all the above statements, I hope I was able to illustrate how the windmill project will negatively affect the environment, the business and most importantly the safety and wellbeing of animals and humans who have invested in this particular area to reside.

With most sincere regards, thank you for your time in considering my perspective as part of the community.

Jacqueline Lai

I sagen om Vindmøller placeret omkring Vievej

Skals, den 3. september 2016

Som ansat på et af Danmarks største Stutterier, et job jeg er meget glad for har jeg dagligt med heste og deres velfærd at gøre. Jeg er ansat som professionel rytter og varetager dagligt træningen af 10 – 12 heste, som fortrinsvis er Hingste. Hingstene udgør en stor del af Stutteriets indtjening og mit arbejde er, at sikre de er uddannet tidssvarende, trænet korrekt og kan gennemfører konkurrencer, der gør dem attraktive som konkurrenceheste for salg men ikke mindst som avlshingste. Jeg har været i springsporten siden jeg var 9 år gammel og i dag som 21 årig har jeg arbejdet professionelt med heste siden 2011 og som rytter rider jeg Internationalt og repræsenteret det Danske landshold i flere år og sammenhænge – sidst her i sommer under Nordisk Mesterskab i Finland.

Jeg er et ungt menneske i et land, hvor jeg sætter pris på, at der tænkes over vores velfærd og at vi som mennesker tænker os om for, hvorledes vi ønsker vores land/verden skal se ud også i fremtiden. Derfor forstår jeg så godt tanken om Vindmølle energi. Det er grøn energi, der kan spare vores land for en masse forurening. Jeg er også en ungt menneske, der har fungeret i en sport, hvor der gennem mange år har været fokus i meget høj grad på vores hestes velfærd og ikke mindst sikkerheden i færden med heste. Her er mange tiltag gjort for at sikre, at hestevelfærd er sat øverst på dagsorden. Da min verden er heste, og jeg lever og ånder for min sport og job i denne verden, er jeg nød til at melde min største bekymring for dette projekt omkring etablering af vindmøller på Vievej.

I mit arbejde specielt med Hingste ved jeg hvor hurtigt ting kan gå, at heste ikke som mennesker bare kan vænne sig til specielt lyde og indtryk. En Hingst er, som en stor maskine og jeg nærer den største respekt og agtpågivenhed hver dag i mit arbejde med disse dyr. For heste er fra natur mistroiske og kan skifte fra arbejdshumør og koncentration til frygt på et splitsekund. Derfor er det helt essentielt, at man i arbejdet med disse dyr har ro omkring sig. Man skal ikke spøge med sikkerhed omkring en Hingst, den er et stort dyr på mange 500 – 600 kilo og har uanede kræfter og den tænker ikke og ej heller fortæller den er bange. En hingst reagerer pr. instinkt og er den bange flygter den fra det som den er bange for.

I mit daglige arbejde på Stutteri Viegaard bruger jeg dagligt vores skønne omgivelser til at træne hestene i. Det er en del af deres uddannelse, at kunne begå sig og koncentrere sig inde – som udendørs. En vigtig del af træningen er også, at ride i terræn af hensyn til at minimerer skader da det er meget vigtigt, at hestene kan træne på flere underlag. En helhed for hestene er, at kunne være ude på fold, stå sikkert og roligt på boks og træner inde og ude gennem hele året. Når hestene er afslappet og veltilpas opnår man en langt bedre og effektiv træning og dermed også en godt resultat heraf. Jeg rider dagligt mellem Låstrupgård og Damgaarden og på alle marker omkring dette område. I mit arbejde har jeg også det daglige opsyn med 2 kinesere, som jeg har ansvaret for når

FREDERIKKE STRØM

de rider. Det giver sig selv, at såfremt vores omgivelser bliver et et problem, at ride i vil dette også medføre, at mit arbejde vil blive meget svært og jeg i givet fald ikke kan have mere urutineret eller i det hele taget andre ryttere med at ride. Heste er jo flokdyr og bliver en bange reagerer de andre på samme vis. Det vil give udfordringer på sikkerhed og i værste tilfælde kunne medføre ulykker, hvor ryttere og heste kommer alvorligt til skade.

Jeg har tidligere i mit professionelle virke arbejdet et sted, hvor der blev etableret Vindmøller. Det betød at vi fra at have glade og veltilfredse heste i stalden stod med problemer som, stressede heste, heste der var svære at holde i form i det daglige – det er foderproblemer og giver mange udfordringer og flere syge heste. Vores brug af dyrlæger steg betydelig på kort tid. Vi oplevede, at det var svært med den daglige træning grundet hestene var stresset og bange og derfor gav det koncentrationsbesvær. Her måtte man opgive, at drive en salgsstald grundet disse betingelser, der langt fra var optimale for træning af heste på højt konkurrenceniveau.

Jeg føler mig overbevist om, at det også i dette tilfælde her, hvor man vil opstille Vindmøller helt tæt på min arbejdsplads vil give betydelige følgevirkninger. Det vil betyde, at jeg også i mit virke som rytter vil få svært ved at holde mine konkurrenceheste optimalt i træning, at jeg vil få et problem med uddannelse af de unge Hingste og ikke mindst det daglige arbejdet med hingstene vil blive besværliggjort. Jeg vil også få et problem fysisk ved ikke at kunne ride fra den ene stald til den anden – grundet de nye omgivelser, hvor jeg vil skulle frygte for, hvornår jeg sidder på en hingst, der reagerer ved flugt. Sluttelig vil jeg være rigtig ked af, at miste mit job grundet, at forretningen evt. ikke vil kunne overleve et sådan tiltag.

Jeg bliver derfor nød til ud fra min bedste professionelle vurdering, mit kendskab og respekt for heste at sige, at jeg **stærkt fraråder**, at man opstiller Vindmøller i dette område omkring Viegården Stutteri. Det er set ud fra både et synspunkt for trivsel og velfærd for hestene, arbejdsmæssige forhold i omgang med hestene men ikke mindst ud fra et meget bekymret synspunkt for skader og ulykker med alvorlig udgang.

Jeg skal derfor venligst anmode og tilslutte mig de mange, der deler synspunkt om, at der ikke opstilles Vindmøller i området.

Jeg håber, at man fra kommunen siden vil finde et andet sted for sin grønne energi, der ikke giver udfordringer for trivsel og sikkerhed for dyr og mennesker.

Med venlig hilsen

Frederikke Strøm

Vievej 13 – Stutteri Viegården

Skals

FREDERIKKE STRØM

DANSK RIDE FORBUND

Til rette vedkommende 04/09-2016

Med baggrund i mange års erfaring med heste og ridesport vil jeg anbefale at der ikke bygges store vindmøller tæt op ad hesteejendomme hvor der trænes heste og afholdes ridestævner.
Heste er flugtdyr og der kan opstå farlige situtiationer i forbindelse med vindmøller tæt på ridebaner, folde, stalde m.m. Jeg tænker især på lyden som kan ændre kraftigt sig ved skiftende vindhastigheder, og den skyggeeffekt vingerne kan have i morgen og eftermiddag/aftentimer, heste er meget påvirkelige af skygger på underlaget de går på.
Stutteri Viegaard ved Skals er et af Danmark og Europa største stutterier, hvor der dagligt trænes et stort antal heste af ryttere fra store dele af verden, endvidere er der planer om et stort stadion til afholdelse af store internationale stævner.
Med baggrund i ovennævnte vil jeg ikke anbefale at bygge vindmøller tæt på Viegaard Stutteri i Skals.

Venlig hilsen

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Viborg Kommune

Prinsens Alle 5

8800 Viborg

5/9-2016

Indsigelses- og bekymringsbrev vedr. vindmøller ved Viegård Stutteri, Skals

Jeg retter henvendelse vedr. planlægning af vindmøller ved Viegård Stutteri i min rolle som DRIF formand, examineret berider og ridecenter-ejer.

Det er en meget bekymrende plan, som jeg er blevet gjort opmærksom på!

Heste, ridning, ridecenter og vindmøller hører slet ikke sammen!

Det er vigtigt, at gøre klart, at det er uacceptabelt at placere vindmøller ved siden af et ridecenter.

Det vil stride mod dyrevelfærd, trivsel og i allerhøjeste grad sikkerhed, både for mennesker og heste.

Man kan umuligt drive et trænings-, uddannelses- og avlscenter så tæt på vindmøller.

Desuden er det evidens baseret, at heste er meget følsomme for skygger – mørke og lyse – og især skygger der bevæger sig. Det kaldes i daglig tale "at hesten ser-spøgelser". Dette kan ikke aflæres – da det er en del af hestens natur og psyke/instinkt.

Det vil give arbejdsbetingelser, som både er under al kritik, frustrerende og livsfarlige.

Lyden kan og vil virke så forstyrrende, at den vil påvirke hestenes adfærd, samt mindske hestenes opmærksomhed og koncentration, som er livsvigtig og en essentiel betingelse for hestens opvækst, udvikling, uddannelse, træning og ridning.

Derfor håber jeg virkelig, at man vil lytte til kompetente fagfolks viden og erfaring med øje for hestevelfærd, sikkerhed. Samt det væsentlige faktum, at Viegård er et ridecenter, hvor man opdrætter og uddanner heste, og i høj grad en arbejdsplads man bringer i fare med den forkerte placering af vindmøller.

Ønskes der yderligere oplysninger eller fag-viden, så er I meget velkomne til at kontakte undertegnede.

Med venlig hilsen

Torben Frandsen

Ex. Berider

Tørring Ridecenter

+45 2331 1772

APPENDIX6.8.1

Til Viborg Kommune
Attention Karl Johan Legård

Vindmølle Park Låstrup
Det overrasker mig meget at for undersøgelsen omkring vindmølle park har været så svag.

Jeg driver et stort stutteri, et af de største varmblods stutterier i EU, har en godkendt lokalplan for internationale ridestævner, kinesisk kulturuge, udstilling af danske landbrugs produkter og dyrskue. Et projekt vi har arbejdet på i to år med kinisiske investorer. Vi har allerede opkøbt 6 gårde og 11 huse (Vieland) for projektet og renoveret disse for mange millioner.

Dette event vil have deltagere fra mere end 20 nationer, 400 heste, hesteejere, familie, sponsorer, ryttere og tilskuere fra hele verden. Stævnet vil løbe over 2 til 3 uger. En enorm omsætningsfaktor på Viborg egnen

Det har været en meget stor investering bare at få faciliteter og jord nok. Vi håber at kunne flytte Vievej ca. 900m allerede i år, så stadion projektet kan på begyndes, når vejen er placeret. Vi er i øjeblikket i Kina for at planlægge stadionbyggeriet.

Jeg driver idag træningscenter for mange danske og udlanske talenter i ridesport. Jeg har selv trænet det danske, det kinisiske landshold og enkelte landsholds ryttere fra Hong Kong. Vi er idag cirka 30 fuldtids ryttere og ansatte plus arbejdskraft udefra for eksempel håndværkere, beslagsmed, maskinstation o.s.v. Ved færdig bygget anlæg forventes 50 til 60 ansatte.

Viegaard Stutteri er blevet opbygget over 30 årig periode.

Her i har vi endelig fået færdig lavet en handelsaftale mellem Danmark og Kina om eksport for heste. Vi har på Låstrupgård opbygget en karantæne stald der er godkendt af veterinær direktoratet som karantæne eksport stald Kina. Denne handelsaftale har vi arbejdet på i flere år og det har været et stort politisk arbejde at for gennemført. De første heste er for to måneder siden eksporteret til Beijing, Kina.

Embedsmænd ved Viborg Kommune kender planen og har deltaget i flere møder, omkring over stånde, så derfor min undern omkring kommunes viden om lokalforhold og lokalplan.

Jeg vil derfor gerne invitere relevante embedsmænd til møde omkring følgende, før kommunen går igang med at lave en lokalplan for vindmølle parken.

1. Dyrevelfærd læs venligst breve fra
-Foulum/Århus Universitet
-Dansk Rideforbund
-Dansk rideinstruktorforening
-Dyrlægerne
-Professionnele ansatte instruktører medarbejdere på Viegaard Stutteri der dagligt for problemer med sikkerheden

Viegard
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APPENDIX6.8.2

2. Sikkerhed heste Underridning, store flokke pa fold, trafikulykker med løse heste.

3. Sikkerhed rytter Underridning og i trafikken

4. Misdannelse af føl og aborter (Portugal effekt)

5. Hvorfor etablere vindmølle park på bygherrens smalleste jordstykke og ikke på hans store arealer ved hans egne huse?

6. Kommunens garanti for erstatning på mere end 90 millioner Kroner til Viegaard Stutteri vil opbygning af vindmølle park. Min advokat vil senere fremkomme det nøjagtige beløb

7. Mine investores advokat eksperter på vindmølle området vil fremkomme med deres erstatningskrav på 76 millioner Kroner. Midstet forventet indtjening og planlœgning af stadion er endnu ikke vœrdi ansat

Jeg kan ikke tage ansvar for hestene og rytternes og trafikkanters sikkerhed i vindmølle område.

Bare forstil en kunde fra USA prøver en hest til flere millioner og denne bliver bange for vindmølle skygger eller lyden. Damen falder af og brœkker et ben eller nakken. Hesten løber ud i trafikken og bliver på kørt og må aflives, eventuel person skade i bilen. Familien til amerikanske dame anlœgger million erstatning for uforsvarlig virksomhedsdrift da man ved at vindmølle er farlige for heste sport og kan ikke forenes med så mange forskellige heste.

Dette eksempel er en hverdags risiko da vi har ca. 200 heste under sadel dagligt
Hvem skal tage ansvaret herfor og betale?
Mine beridere, kursister, ryttere, udenlandske elever, kunder og jegselv kan ikke arbejde fagligt forsvarligt under udefra kommune forstyrelser.
Tab på grund af at kineserne ikke tør risikere at trœne på anlœgget
Hvem skal erstatte tabet?

Håber på snarest muligt et møde

Venlig Hilsen
John Byrialsen

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Materiale fra Aarhus Universitet Foulum

Anna Dorte Nørgaard

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Sendt: 11. oktober 2016 13:56
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Emne: SV: Vindmølleprojekt Låstrup
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Kategorier: Journaliseret på 16/16628 - Lokalplan nr. 472 for teknisk område til vindmøller ved Låstrup samt tillæg nr. 64 til kommuneplan 2013-2025

Kære Anna Dorte

Jeg vedhæfter et kort over de områder, hvor vi har lavet forsøg på Viegaard Stutteri (indenfor den røde linje). Vi har i de senere år været over et meget stort område, fordi vi har lavet undersøgelser af udegående hopper og føl, og de gik på forskellige folde omkring stutteriet.

Det er desværre ikke muligt for mig at vide, hvor eventuelle fremtidige forsøg vil skulle gennemføres, dels fordi forskningsprojekterne afhænger helt af de opgaver, vi får ind (dvs. vi kan heller ikke forudse, om vi skal bruge føl, ungheste eller rideheste), og dels af stutteriets management (altså hvor f.eks. avlshopper og føl opstaldes og afgræsser det pågældende år).

Med hensyn til hestes frygtreaktioner og risikoen for ulykker, så vedhæfter jeg en række videnskabelige artikler. Der er desværre ikke lavet videnskabelige undersøgelser af hestes reaktioner på vindmøller, hvorimod mange undersøgelser bruger pludselige lyde og bevægelser til at teste hestes frygtreaktioner (se nogle eksempler vedhæftet). Jeg vedhæfter også nogle artikler vedr. rideulykker (se Hawson et al, Keeling et al og Thomas et al), hvor ridning ifølge Danmarks Statistik ligger på en kedelig 3. plads efter håndbold og fodbold. Hvis antallet af udøvere og alvoren af ulykkerne tages i betragtning anses ridning som en af de farligste sportsgrene, og netop hestens frygtreaktioner betegnes som en af de væsentligste ulykkesårsager.

Med venlig hilsen
Janne

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Sendt: 29. september 2016 11:49
Til: Janne Winther Christensen
Emne: VS: Vindmølleprojekt Låstrup

Kære Janne Winther Christensen

I jeres bemærkninger til vindmølleplanlægning ved Låstrup skriver I, at Aarhus Universitet gennemfører forskellige forskningsprojekter på Viegaard Stutteri.

Forvaltningen behandler p.t. alle indkomne høringssvar, hvorefter de forelægges for Klima og Miljøudvalget.

I den sammenhæng vil vi gerne have supplerende oplysninger om hvor på stutteriet, I gennemfører forskningsprojekter nu og i fremtiden, så vi kan vurdere konkrete afstande mellem eventuelle vindmøller og forskningsaktiviteter. I den sammenhæng vil vi gerne have et kort med en indtegning af de stalde, folde mv. som er udgangspunktet for forskningen.

I refererer til undersøgelser og dokumentation for hestes frygtreaktioner. Vi vil sætte pris på, hvis I kan henvise os til relevante dele af resultater for disse undersøgelser, som relaterer sig til noget der kan minde om vindmøller.

Den dokumentation, I fremsender, vil blive forelagt politikerne i forbindelse med sagsbehandlingen af vindmølleprojektet.

Vi vil sætte pris på en tilbagemelding med de nævnte informationer inden den 12. oktober 2016, for at det kan indgå i den politiske behandling. Alternativt vil vi gerne have en tilbagemelding om, hvornår vi eventuelt kan forvente en tilbagemelding.

I er meget velkomne til at kontakte mig.

Med venlig hilsen

Anna Dorte Nørgaard
Planlægger

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Til Viborg Kommune Plan

Vedhæftet fremsendes kommentar til vindmølleprojektet ved Låstrup.

Med venlig hilsen
Janne Winther Christensen

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Fear reactions in trained and untrained horses from dressage and show-jumping breeding lines

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ABSTRACT

Horses' fear reactions are hazardous to both horses and human beings, but it is not clear whether fear is influenced more by training or by other factors such as genetics. The following study was designed to detect differences between young, untrained (*U*) and older, well-trained (*T*) horses of dressage (*D*), show-jumping (*J*), and mixed (*M*) genetic lines with regard to intensity of reaction and ease of habituation to a frightening stimulus. In five consecutive trials, 90 horses were exposed to a standardized fear-eliciting stimulus where intensity and duration of the reactions were recorded. Repeated measures analysis showed that flight reactions by J were less intense ($p < 0.05$) than those by D or M regardless of training status or age. Habituation to the stimulus over time was not significantly ($p > 0.1$) different between the disciplines, as indicated by similar slopes for all measurements, but reaction vigour declined faster for T than for U. These findings indicate that there may be a genetic basis for less strong, though not shorter-lasting, fear reactions in J compared to D or M lines of horses. Research including the estimation of genetic correlations between traits related to fearfulness and to performance would be required to verify this assumption.

1. Introduction

Horseback riding contributes to about one-quarter of all fatal sport injuries (Heitkamp et al., 1998), and Keeling et al. (1999) found that as much as 27% of horse-related accidents are due to fear reactions of the horses. Therefore, identifying factors influencing the horses' behaviour may ultimately help to reduce the number of accidents.

The two main sport disciplines for which warmblood horses are bred are dressage and show-jumping (cp. Koenen et al., 2004) and accordingly they represent a major part of the total English riding horse population: for example, of all competition starts in Germany 61% and 29% are in show-jumping and dressage classes, respectively (FN, 2009). Although only 32% of riders in Germany have ambitions to compete at advanced or higher level competition classes, 75% of riding-club members and 52% of riders not associated with riding clubs follow the classical English riding theory, i.e. dressage and/or show-jumping (IPSOS, 2001). Riders in Europe commonly believe that dressage horses are more nervous, and thus show stronger and/or more frequent fear reactions than show-jumping horses (Lundin, 2005). This view is supported by Hausberger et al.'s (2004) study, which (according to e.g. Boissy's (1995) or Davis' (1998) definitions of fear and anxiety) compared anxiousness of horses used for many different types of work and found dressage horses to be among those with the highest emotionality, whereas show-jumping horses were among those with lower emotionality. Also, Heitkamp et al. (1998) found that the risk of being involved in an accident is approximately equal for dressage and show-jumping riders but that injuries were less severe with dressage riders

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than with show-jumping riders. These statistics are nevertheless surprising as common sense suggests that, due to the nature of show-jumping, the risk of falling would be much higher for show-jumping riders than for dressage riders. These equal numbers of accidents in the two sports may in part be attributed to overall less time spent riding show-jumping (one-third of the time spent riding dressage (Heitkamp et al., 1998)) even if the rate of falling off is higher per unit of time spent riding. However, to some extent it may also be a result of dressage horses exhibiting stronger or more frequent fear reactions than show-jumping horses resulting in people falling off more often than might be expected from riding on the flat.

In the dressage discipline, horse and rider perform a series of figures in an arena, and the horse has to show the gaits walk, trot, and canter as well as transitions within and between these gaits (Fédération Equestre International (FEI), 2006). Since the team of horse and rider is judged based on the harmonious appearance of their performance, dressage horses are selected and/or trained to be very sensitive to the rider's cues, so that the rider can communicate with the horse by minimal, ideally invisible, cues. In show-jumping, horse and rider are required to complete a course of obstacles and, depending on the type of competition, they usually have to ride as error-free and/or as fast as possible. Consequently, show-jumping horses are selected and trained to have efficient strides and good jumping skills to enable them to jump the challenging obstacles. In contrast to dressage, the style of the performance is not usually evaluated, and therefore, the communication from the rider to the horse tends to be less subtle, its main focus being on the immediate reaction of the horse.

Given the different demands on the horses used for show-jumping and dressage and the low, or in some cases even negative genetic correlations between traits important for the two disciplines (Brockmann, 1998), breeders of warmblood horses often try to focus on breeding a horse that is particularly good in either dressage or show-jumping, leading to the creation of genetic "lines" of horses within one breed. To ease selection of appropriate mates and to enhance the breeding success, a number of European warmblood breeding associations (Koenen, 2002) started using the now well-established *BLUP* (Best Linear Unbiased Prediction) method of breeding value estimation. Among these horse breeding associations a few (e.g. Hannoverians (Verband hannoverscher Warmblutzüchter e.V., 2003) and Swedish Warmblood (Arnason, 1987)) combine breeding values for single traits into separate indices for dressage and for show-jumping merit to simplify discipline-focused breeding. Traits that are considered in the dressage index for these warmblood breeds have high heritabilities between 0.3 (World Breeding Federation for Sport Horses (*WBFSH*), 2007) and 0.43 (Gerber Olsson et al., 2000), and traits considered in the show-jumping index have moderate to high heritabilities between 0.15 (WBFSH, 2007) and 0.43 (Gerber Olsson et al., 2000). These comparatively high heritabilities indicate that the traits in question are under strong genetic control, demonstrating that the indices do reflect the animals' genetic potential.

However, genetic selection for specific traits often leads to physiological changes that also impact a variety of other traits. Unwanted side effects of selection for specific traits, caused by pleiotropy or genetic linkage between traits (e.g. associations between fearfulness and production traits in fowl (Schütz et al., 2004)), or causal relationship between wanted and unwanted traits (e.g. in cattle the increased occurrences of dystocia as a consequence of selection for increased muscle growth (Ménissier, 1977)) are well documented in farm animals, as reviewed by Rauw et al. (1998). In the same way in horses, it may be possible that the (genetic) selection for high sensitivity to tactile stimuli (to ease cueing by the rider in dressage) goes along with a lively temperament and a generally high sensitivity to environmental stimuli, including frightening stimuli. On the other hand, show-jumping ability is linked to muscle composition, such that the better the horse's performance in show-jumping the higher the percentage of fast myosin heavy chains (enabling fast rather than endurance action) in the *gluteus medius* (Barrey et al., 1999). Possibly, these heritable differences in muscle fibres will also impact horses' behaviour during other, e.g. frightening situations, such that good jumpers will show stronger, but short-lived fear reactions. Then again, it may be possible, that the genetic basis of reactivity is similar in horses of dressage and show-jumping lines within the same breed, but that differences in training and training environment lead to an overall decreased sensitivity, and therefore decreased reactivity, in show-jumping horses and/or the development of higher sensitivity in dressage horses.

Therefore, the objective of this research was to detect potential differences in fear reactions with regard to strength and habituation between trained and untrained horses of dressage and show-jumping lines. Our hypotheses were that: (i) dressage horses react more strongly to a fright than show-jumping horses, and that (ii) these differences are inherited rather than due to differences in training.

2. Materials and methods

2.1. Animals

A total of 90 warmblood riding horses, consisting of 43 Swedish Warmblood (*SWB*) and 47 Hanoverian (*HAN*) horses, of which 28 were Halfbloods (*HB*, i.e. having a Thoroughbred parent or grandparent, the remainder pedigree being SWB or HAN), were tested, and they ranged between one and 17 years of age. Horses that had been ridden for more than half a year (i.e. horses older than three years) were allocated to the treatment trained (T), while horses with no ($n=6$), less than six weeks ($n=27$) or up to half a year of riding experience ($n=9$) were considered untrained (U) as the initial training tends to be similar for dressage and show-jumping horses. Mean years in training per group are given in Table 1. Trained horses were selected for this study only if they were, according to the owner and to our knowledge, trained and competing (if applicable) solely in one of the two disciplines. In addition, a horse was considered to belong to one genetic line (D or J) if it had a minimum breeding value of 120 index points in the respective discipline, and at least 10 points less with no more than a total of 119 in the other discipline. For horses without own

Table 1
Overview of horses' distribution across locations and gender, and average years in training as well as genetic merit indices by discipline and training status.

Discipline	TS	Location					Sex			N	Years in training	Genetic merit index	
		A	B	C	E	F	m	g	s			Dressage	Jumping
D	T	0	3	8	3	0	3	4	7	14	5.6 ± 4.5	133.8 ± 12.6	102.6 ± 13.0
	U	9	3	0	3	0	2	2	11	15	0.12 ± 0.13	126.0 ± 9.6	102.0 ± 9.4
J	T	0	0	6	4	7	4	6	7	17	4.2 ± 3.6	100.1 ± 9.0	131.7 ± 7.4
	U	10	0	0	2	2	2	1	11	14	0.15 ± 0.25	99.2 ± 10.8	133.5 ± 9.7
M	T	0	3	5	6	3	5	5	7	17	3.7 ± 3.5	106.0 ± 14.3	101.6 ± 16.9
	U	10	0	0	3	0	0	1	12	13	0.1 ± 0.05	91.7 ± 13.8	96.8 ± 12.2

D: dressage, J: show-jumping, M: mixed disciplines, TS: training status (T: trained, U: untrained), m: mare, g: gelding, s: stallion, *N*: total number.

genetic evaluation ($n = 38$), the requirement was that both its parents stemmed from a genetic line of the same discipline (D or J). A pedigree breeding value was then calculated based on the sire's and, if available, dam's breeding values, and the above rules were applied. These limits for the index values ensured that horses were evaluated in one of the disciplines higher than the average (100) plus one standard deviation (20) and statistically no more than average in the respective other discipline. Owing to a large number of horses with 'mixed genetic background' who neither fulfilled the above criteria for categorization into group D nor into group J, a third treatment group was created for these animals, called mixed (M). All horses grouped into the M category had an average genetic potential (i.e. index values deviating less than 20 points (one standard deviation) from 100 points) in both disciplines D and J. Therefore, it can be assumed that M represent the 'average' riding horse population, rather than "all-round" horses that are highly talented in both disciplines D and J. The total numbers of horses per groups were 14, 15, 17, 14, 17 and 13 for DT, DU, JT, JU, MT, and MU, respectively (Table 1).

2.2. Facilities

Trials were conducted at five different indoor riding arenas. Each horse was tested in its home environment, which it was familiar with from regular turnout or riding, to ensure that novelty of the test environment did not bias the results. The position of the horse relative to the feed bucket (in the middle of the arena and directly in front of the horse), the stimulus (diagonally behind the horse at a distance of 8.5 m), the handler (diagonally in front of the horse at a distance of approximately 1.5 m), the observer (diagonally in front of the horse at a distance of 8.5 m) and the video camera (behind the stimulus) remained the same throughout all locations with all people or objects (except the feed bucket) situated at the horse's left side (Fig. 1).

2.3. Test procedures

Horses were equipped with a halter and a lunging line and led by the unfamiliar handler in the arena directly to a feed bucket containing oats. When the horse started feeding, the handler quietly positioned herself approximately 1.5 m away from the horse to the front and left. After the horse had been feeding for 20 s and when it had its head in the bucket, the stimulus was elicited. The stimulus consisted of a black plastic bag (0.4 m × 1 m) that was quickly moved by the observer 1 m along the floor by pulling the string tied to it. The bag contained a small amount of sand to give it some weight. If the horse reacted, the handler extended the lunging line as needed, following the horse if necessary, but otherwise remained as passive as possible so as to minimize disturbance of the horse's movement. This set-up was chosen to test horses' fear reaction in the presence of a handler, as well as a safety measure in the case of an overreaction, even if the latter event did not occur. The horse was given a maximum of 1 min to return to the bucket. When a horse had taken a mouthful of food or after it exceeded the maximum time, it was led out of the arena where it could briefly see other horses. While the horse was out of the arena the stimulus was returned to its original position. The horse was then led back into the arena and the next trial was started, and so on until a horse was tested 5 times. The total testing time for all five trials took less than 20 min after which the horse was returned to its usual stable or paddock.

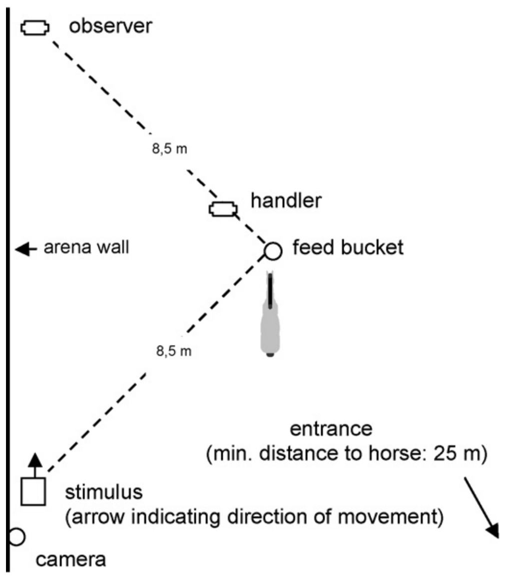

Fig. 1. Overview of experimental set-up showing the horse's position in relation to stimulus, feed bucket, handler and observer.

2.4. Observations

Live observations were taken by the observer and included for each trial the reaction vigour (*RE*), time to resume chewing (*TC*), and time to resume feeding (*TF*). Video observations were taken for later analysis to validate the original observer's results for RE with repeated observations by the same and a second observer. This second observer was blind to the horses' disciplines and training status and had no previous horse experience. RE was classified into one of the following five categories of reaction (adapted from Christensen et al., 2006):

- Flight: The horse jumps to the side and gallops for more than four strides away.
- Sidesteps: The horse jumps to the side and trots or gallops away for more than two but no more than four strides (Not as energetic as "flight").
- Alert: The horse quivers and may take up to two steps to the side.
- Head up: The horse throws its head up, stops eating but does not move away.
- None: The horse may or may not direct its attention (turn ear and/or eye) to the stimulus but does not stop eating/chewing or lift the head in response to the stimulus.

TC was defined as the time from the eliciting of the stimulus until the horse showed first signs of relaxing the mouth and recommencing chewing motions. This variable was chosen because chewing and licking in horses is subject to many interpretations and it occurred reliably since the horses had been eating just before the fright, so there were usually oats left in the mouth.

The third observed variable was the time measured from eliciting the stimulus until the horse returned to the bucket and took the first mouthful of oats (TF). The maximum time allowed for the horse to return to feeding was 60 s. If a horse did not return within the allotted time, 60 s was noted as the return-time in order to be able to include the results into the statistical analysis.

Also, for each trial, weather conditions (temperature, cloud cover and wind) and, if applicable, abnormal events such as whinnying of other horses outside the arena, which might have distracted horses, were marked down on the observation sheet. Additionally, horses' defaecations were recorded during the trials.

2.5. Questionnaires

For each horse, a questionnaire was filled out by the person most familiar with the horse (i.e. either the owner or the principal rider). This was done to obtain information on age, sex, pedigree, breed, discipline (dressage/show-jumping), level of performance, years/months in training, and the type and amount of riding, turnout and feed for each horse. In addition, the rider was asked to rate the horse's sensitivity to her/his aids, its willingness to work, its ease of learning, and its appetite for feed, and oats in particular, on scales from 1 to 5. The riders were also asked to rank their relationship with the horse on a scale from 1 to 10 to assess how well they knew the horse and if the horse was a sports-partner or more like a friend to the rider.

2.6. Data analysis

All calculations and analyses were conducted in SAS 9.1 (http://www.sas.com/). Each of the three dependent variables (RE, TC and TF) was analysed using a mixed model (PROC MIXED) with repeated measures over test number (1–5), with discipline, training status, test number and, if significant ($p < 0.05$), their interactions as fixed effects. Further details about trial-specific circumstances (weather conditions and distractions) and general horse characteristics, management and background, as obtained from the questionnaire, were considered as covariates in the model, but only included if they were significant ($p < 0.05$). Degrees of freedom were estimated using Satterthwaite's formula (Littell et al., 1996). Least square means were calculated for individual comparisons if the main effects were significant. Linear regression (PROC REG) was used to estimate slopes of responses over trials one to five. The slopes were then analysed using a mixed model considering discipline, training status, their interaction and the owner's rating of the horses' learning speed (in the case of RE) or the appetite (in the case of TC and TF) as a fixed effect.

The measurements for RE were transformed into numbers from one to five for the categories "none" to "flight", respectively, and considered a continuous variable in the analysis as is common practice (e.g. Kestin et al., 2001; Mason et al., 2004; Christensen et al., 2006) with this type of variables. Since no horse exceeded the 60 s time limit to resume chewing (TC) and on only 12 out of 225 occasions was the 60 s time limit exceeded for a horse to resume feeding (TF), the values were expressed as fractions of 60 s, and likewise analysed as continuous variables, rather than survival data. In addition, square root transformation was used for values of TF to achieve normality. Pearson's correlation (PROC CORR) coefficients were calculated within and across all three variables for the trials one to five to assess interrelatedness.

A second 'blind' observer re-evaluated 24 randomly chosen trials. Kappa statistics were calculated separately for D and for J to test for inter-observer reliability and potential discipline-specific bias of the original observer. Not enough defaecations were observed to be included in the analysis.

This research was approved by the Swedish Animal Welfare Agency.

3. Results

The original observer and the validating observer agreed above chance (weighted kappa 0.72 and 0.5, confidence intervals 0.54–0.89 and 0.197–0.803 for dressage and show-jumping horses, respectively), and the exact test of symmetry did not indicate bias for either of the two disciplines.

3.1. Reaction vigour

D (3.42 ± 1.72 (overall mean RE score $\pm$ standard deviation)) and M (3.42 ± 1.58) reacted more strongly

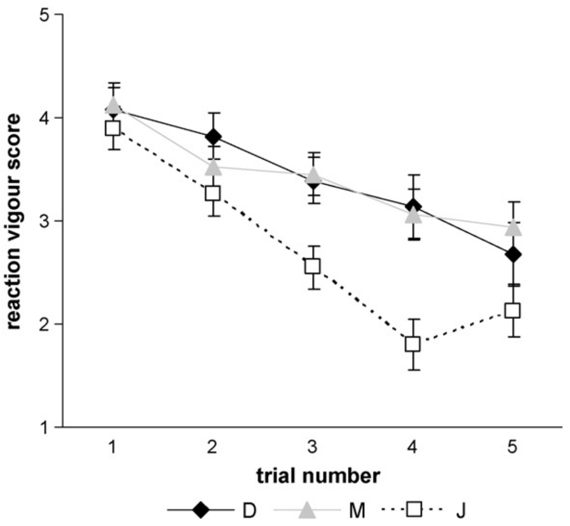

Fig. 2. Mean (±SE) reaction vigour by discipline over trials. (D: dressage, M: mixed disciplines, J: show-jumping).

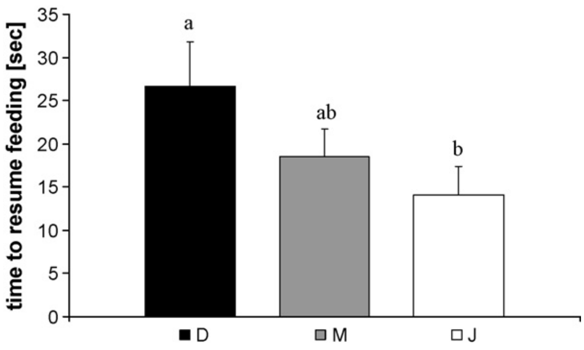

Fig. 3. Mean (±SE) time to resume feeding by discipline (D: dressage, M: mixed disciplines, J: show-jumping; different letters denote statistically significant differences between groups at $p < 0.1$).

($F_{2,75.6} = 7.38$; $p = 0.001$) than J (2.73 ± 1.56), regardless of training status U or T ($p > 0.1$) (Fig. 2). Reaction vigour declined significantly ($F_{4,222} = 19.29$; $p < 0.0001$) over trials one to five ($p = 0.060$ between two and three, and three and four, but $p = 0.993$ between four and five), indicating that habituation took place. However, contrary to the absolute strength of reaction, there were differences in habituation to the stimulus between trained and untrained horses ($F_{1,88} = 6.81$; $p = 0.010$), such that T habituated faster than U to the stimulus, as indicated by different estimated slopes (−0.51 (T) versus −0.21 (U)), regardless of disciplines D, M or J. The only additional significant effect in the model was distractions ($F_{5,199} = 4.14$, $p = 0.007$) during the trials (on two instances when the horses insisted on turning to face the stimulus during feeding, they reacted more strongly (4.63 ± 0.64) than horses in other trials when there were no (2.99 ± 0.34) distractions or other (3.32 ± 1.18) distractions such as noise).

3.2. Time to resume chewing

There were no significant differences ($p > 0.1$) in TC between disciplines (D: 2.1 ± 0.7 s; J: 2.6 ± 0.6 s; M: 2.4 ± 0.6 s), training status (T: 2.3 ± 0.4 s; U: 2.4 ± 0.6) or their interactions. However, the effect of trial number (one: 3.9 ± 0.48 s; two: 2.7 ± 0.48 s; three: 1.9 ± 0.48 s; four: 1.2 ± 0.48 s; five: 2.3 ± 0.48 s) was significant ($F_{4,172} = 14{,}96$; $p < 0.0001$) with significant differences ($p > 0.05$) between all pairs of trials, except between trial number three and four ($p = 0.972$).

Slopes for TC were numerically slightly negative but not, or only tended to be significantly (D: $p = 0.103$; J: $p = 0.120$; M: $p = 0.098$, T: $p = 0.066$, U: $p = 0.086$) different from zero, and there were no differences between any of the groups DT, DU, JT, JU, MT or MU. Horses turned out alone to pasture and horses receiving more weekly turnout took longer to resume chewing than horses turned out in company with other horses or horses receiving less turnout, respectively (both $p < 0.05$). In addition, horses rated by their owners to be faster learners or to have lower appetite, took longer to resume chewing than those horses rated to be slower learners or to have larger appetite, respectively (both $p < 0.05$).

3.3. Time to resume feeding

The effect of discipline on time to resume feeding tended to be significant ($F_{2,44} = 2.73$; $p = 0.076$) with J (14.1 ± 3.3 s) taking significantly ($p = 0.037$) less time to resume feeding than D (26.7 ± 5.1 s); however, neither D ($p = 0.257$) nor J ($p = 0.105$) was significantly different to M (18.5 ± 3.2 s; Fig. 3). In addition, horses receiving higher rather than lower amounts of concentrate returned more quickly ($p = 0.020$) to feeding, horses ridden more often (up to 7 times/week) had shorter latencies to resume feeding than horses ridden less often ($p = 0.026$), and horses with higher Dressage index values took longer to return to feeding ($p = 0.004$). However, the effect of trial number was not significant ($p > 0.1$), and slopes were not significantly (D: $p = 0.705$, M: $p = 0.963$; J: $p = 0.779$, T: $p = 0.622$, U: $p = 0.594$) different from zero (nor from each other) indicating that there was no significant habituation in TF in any of the groups.

3.4. Correlations between variables

Within each of the three variables RE, TC, and TF, measurements for all trials (1–5) were positively correlated ($p < 0.05$) with each other, indicating that horses with a stronger reaction in one trial also tended to show stronger reactions in the other trials. In addition, within each trial (1–5) TC showed significant, positive correlations ($p < 0.05$) with the values of RE and TF of the same trial, with the exception of the second trial, in which the correlation between TC and RE was not significant. However, correlations between RE and TF were non-significant for all trials.

RE and TF, but not TC, showed significant negative correlations with a horse's show-jumping index points: Pooling data of all D, J and M horses, the correlation of show-jumping index points with mean RE was −0.24 ($p < 0.0001$; Fig. 4); however when considering the disciplines separately, this correlation was significant only for M (−0.20; $p = 0.029$), but not significant for D or J (both $p > 0.1$).

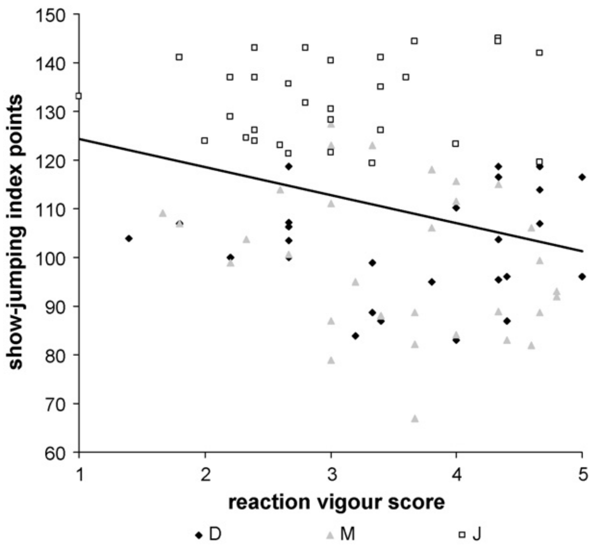

Fig. 4. Scatterplot showing the relationship between horses' show-jumping index points and average reaction vigour score by disciplines (D: dressage, M: mixed disciplines, J: show-jumping).

Similarly, the overall correlation of show-jumping index points with TF was −0.162 ($p = 0.017$), but when considering the disciplines separately, it was only significant for D (−0.297, $p = 0.036$). Neither RE, nor TF or TC were significantly ($p > 0.1$) correlated with the dressage index points.

4. Discussion

The results of the present study confirm the impression among many riders that dressage horses are more easily scared than show-jumping horses. However a careful analysis including horses with mixed genetic lines shows that in reality it is the show-jumping horses that are reacting significantly less than other groups of horses, not that dressage horses are reacting more. This difference likely is a genetic effect since the difference was apparent in both trained and untrained horses. Further confirmation of the genetic effect of reduced fear reactivity in the show-jumping lines comes from the significant, negative correlations between the genetic potential for show-jumping and the behavioural responses to the stimulus. Correlations between horses' behaviour in learning tests and later, phenotypic performance in show-jumping have also been observed by Visser et al. (2003), providing additional evidence of a link between show-jumping and behaviour traits. There were no such correlations in the genetic potential for dressage. The rate at which horses of the different lines habituated to the stimulus, i.e. the reduction in the intensity of their reaction, differed between T and U, but not significantly between disciplines, implying that the older, trained, and therefore more experienced horses learned faster irrespective of their type of training (D or J).

4.1. Reaction vigour

The clear decline of reaction vigour over repeated trials as observed in the present study is in accordance with established research on habituation to fear stimuli (e.g. Christensen et al., 2006) and, together with the acceptable inter-observer agreement in these observations, indicates that our categories for this measurement are valid and useful. Also, average reaction scores were in the same range as reported by Christensen et al. (2006) using a very similar scale. This may further support the validity of this type of measure, although comparisons across these studies may not be appropriate due to differences in the experimental set-up. For example, in the present study, but not in the study of Christensen et al. (2006), all horses visually perceived the stimulus mostly with their left eye, and it has been shown (e.g. in poultry by Andrew et al., 1980) that the perception or processing of fear stimuli differs between the left and right hemisphere of the brain.

Results for the behavioural measurements are in accordance with Hausberger et al.'s (2004) findings of higher levels of anxiety in dressage compared to show-jumping horses. (Although the terms anxiety and fear describe fundamentally different traits (e.g. Davis, 1998), anxiety is closely related to fear such that more aroused (e.g. anxious) animals are likely to show stronger startle and fear reactions than less aroused individuals (e.g. Brown et al., 1951).) Since the differences in fear reactivity between D and J in our study existed already in horses not yet subjected to discipline-specific training, differences are likely inherited rather than achieved through training. However, given that the intensity of the reaction by M and D were similar, and M correspond to average riding horses, it appears that J have weaker than average fear reactions rather than D having stronger than average fear reactions. This implies that selection for increased sensitivity in dressage horses is either not taking place, or the sensitivity to riders' cues is (genetically) unconnected to general sensitivity that would result in increased fear reactions. The latter is supported by Lansade et al.'s (2008) findings that horses' reactions to two stimuli each acting on a different sense (e.g. a tactile and a visual stimulus) are not necessarily correlated on the phenotypic scale. In contrast, it appears that horses genetically specialized in show-jumping are less reactive than horses with no such specialization. This is further supported by the negative correlations of the show-jumping (but not dressage) index points with reaction vigour and time to resume chewing, indicating that the greater the genetic potential for show-jumping ability, the lower the horse's fear reaction. A potential causal factor could be that good show-jumping ability requires boldness (i.e. a general lack of fear) of the horse in order to attempt and clear high fences.

4.2. Time to resume chewing

Time to resume chewing was originally considered a measure of the time to calm down, as it was hypothesised that recommencing chewing would indicate the point in time at which the horse's attention was no longer directed exclusively towards the stimulus, but also to the remaining feed in its mouth. However, the divergent results between reaction vigour and time to resume chewing suggest that either the above assumption is incorrect or that TC is a measure of the horse's general attention span and/or feeding motivation, unrelated to fearfulness. Alternatively, TC may indicate whether the horse has a more active or a more passive coping style with regard to stress (cp. e.g. Wechsler, 1995). Lastly, TC may also be related to acute stress, such that horses (similarly to human beings (e.g. Garrett, 1987)) experience a dry mouth as a consequence of the activation of the sympathetic adrenal medulla system and suppression of anabolic processes such as digestion including changes in saliva production.

4.3. Time to resume feeding

Although less straightforward than with the reaction vigour, measures of TF also point to a genetic basis for weaker fear reactions in J compared to D. However, it is surprising that latency to feed correlated with TC but not with RE. Time to resume feeding has been successfully used to indicate fear in other species, for example, by Boissy and Bouissou (1995) in Holstein heifers, and Christensen et al. (2005) observed reduced feeding in horses during presentation of novel stimuli. On the other hand, TF is likely also correlated to distance moved, and this was not related to anxiety in horses as assessed by horse's caretakers (Momozawa et al., 2003). However, this incomplete agreement between the outcomes of the different variables may be due to different motivational systems involved in the measures of TF and TC (both feeding motivation and fear) and RE (presumably mostly fear). Oats are generally highly palatable to horses, so feeding motivation may have been stronger than fear motivation in the present study compared to animals in other studies such as the cows in Boissy and Bouissou's (1995) study. Although, controlling for the horse's general appetite, or its liking of oats as rated by the owner, did not influence TF measures.

Not surprising is the negative correlation between amount of riding and latency to feed, as a larger workload may both lead to a larger appetite, as well as reduced fear due to more frequent exposure to diverse stimuli. Positive effects of increased turnout time on abnormal behaviour of dressage horses were also noted by McGreevy et al. (1995) who found reduced occurrences of stereotypic behaviour with increasing time spent out of the stable. The fact that the horses receiving more concentrate feed on a daily basis also appeared to be more motivated overall to feed may be explained by these horses requiring larger amounts of feed.

Although age and training were confounded, it is difficult to avoid in an experiment under field conditions because almost all riding horses start their training around the age of three. This is unfortunate as generally, younger horses are thought to be more fearful than older animals (e.g. Grzimek, 1944). Surprisingly, though this was not confirmed by our measures of TF (nor RE) with U not taking significantly longer than T to resume feeding. Then again, a number of other studies regarding horses' fear reactions (e.g. Hausberger et al., 2004; von Borstel, 2008) failed to detect any significant age effects, indicating that age-related factors such as experience, exercise level and health may actually be more important than age alone. The lack of significant habituation as assessed by TF may possibly be the result of increased satiation leading to lowered feeding motivation over successive trials, counteracting the decreased fear reaction.

5. Conclusions

Results of the present study indicate that the unexpectedly low numbers of accidents with show-jumping horses may indeed be to some extend the consequence of lower than average fear reactions in show-jumping horses and that these differences are predominantly due to genetic differences. However, before beginning genetic selection for low reactivity, careful investigations are needed with regard to other, potentially unwanted side effects of low fearfulness such as a less desirable temperament. One immediate implication of the present findings is, however, that in the interest of safety, leisure riders should be recommended to select horses with high genetic merit in show-jumping.

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Responses of horses to novel visual, olfactory and auditory stimuli

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Abstract

Responses of horses towards fear-eliciting stimuli can have important consequences for both human and horse safety. This experiment was designed to investigate behavioural and heart rate (HR) responses of horses to novel visual, auditory and olfactory stimuli. Twenty-four 2-year-old, previously unhandled, stallions were habituated to receive a food reward from a container in a test arena. Each horse was exposed to three 2 min tests in a balanced design where in addition to the feed container, either a traffic cone (visual test), white noise (auditory test) or eucalyptus oil applied to the inside of the container (olfactory test) were used as the novel stimuli. Compared to the control, less time was spent eating during all tests. There was no difference in locomotion activity in the different test situations, but presentation of the novel visual and auditory stimuli elicited significantly increased HR responses in the horses, compared to their response to the arena without novel stimuli (control), whereas there was no increase in HR response to the olfactory stimulus. However, during the olfactory test, the horses had an increased number of eating bouts and became more vigilant towards their surroundings, whereas during the visual and auditory tests, more time was spent alert towards the stimulus. The horses also took significantly more steps backwards in response to the auditory test. The heart rate responses correlated between tests and reflect a non-differentiated

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activation of the sympathetic nervous system, while the behavioural responses were linked to the type of stimulus.

Keywords: Horses; Novelty responses; Fear; Behaviour; Heart rate

1. Introduction

The appropriate response of a horse towards a potentially dangerous stimulus has been important to its survival through millions of years in the wild and domestic horses respond to perceived threats and novelty in much the same way as their wild ancestors. For instance, horses tend to react with a rapid flight response when alarmed and to avoid potentially fear-eliciting situations in general, e.g. they do not approach threatening stimuli and they tend to respond nervously to novelty in a known environment. Responses towards novelty have often been used in tests of fearfulness or emotionality in animals (Gray, 1987; Boissy, 1995). Novel object tests have been applied to a wide variety of animal species from rodents, to poultry, fish, carnivores and prey animals (e.g. Hemsworth et al., 1996; Malmkvist and Hansen, 2002; Meehan and Mench, 2002; King et al., 2003; Sneddon et al., 2003). Like other prey species, the horse's sensory systems have adapted to facilitate early detection of danger (Saslow, 2002). Horses probably use a combination of visual, auditory and possibly olfactory cues for detection of danger. Currently, we have little knowledge of how horses respond to potentially fear-eliciting situations, which act on their different senses.

In contrast to predators, where exploration is an important part of localising food, the survival of many prey species in their natural environment is less dependent on the tendency of the animal to explore. Responses in novel object tests, therefore, may reflect exploratory motivation, fearfulness or simply that the animal is not interested in the object. In order to be able to interpret responses, it is required that the animal under study is motivated to approach the test object, for instance through the use of positive reinforcement (e.g. food or social partners), thereby creating a motivational conflict between avoiding the novelty and approaching the reward (e.g. Boissy and Bouissou, 1995; Désiré et al., 2003).

In prey species, it is especially likely that responses to suddenness are stronger than responses to novelty per se, due to similarities with moving predators. In this experiment, we separate novelty from suddenness, focussing only on the effects of novelty in a known environment. This is in contrast to previous studies of novelty responses in horses, which have included exposure to a combination of novelty and suddenness (e.g. Visser et al., 2001, 2002; Momozawa et al., 2003).

It is hypothesised that exposure to novelty causes the emotional state fear, which may be reflected in changes in behaviour, an increase in heart rate and neuroendocrine changes. The body has two principally different pathways of reaction to perceived danger: the immediate reaction of the sympathetic nervous system and the slower endocrine secretion of cortisol (Guyton and Hall, 1997). Sympathetic stimulation increases both the rate and force of contraction of the heart, preparing the organism for flight. Although behaviour and heart rate responses are often linked, they may also occur separately. The aim of this study was to investigate this interrelationship in different test situations. The present experiment was designed to explore: (i) whether horses show different behavioural responses to novel visual, olfactory and auditory stimuli under standardised conditions; (ii) whether behavioural responses reflect heart rate responses; (iii) whether behavioural and heart rate responses are correlated between tests.

2. Materials and methods

2.1. Animals and housing

A total of 24, 2-year-old Danish Warmblood (*Equus caballus*) stallions from a large stud were used in this study. Three breeding stallions sired the colts, of which the majority were born at the stud, others were purchased after weaning at six months of age. All colts were kept on pasture with the dam before weaning and were subsequently housed in large groups in straw-bedded boxes with access to outdoor areas during the winter. The colts received a minimum of handling, only for necessary veterinary or farrier treatment. During the summer (May–October), the colts were pastured in a large enclosure (30 ha) with hills, natural vegetation and access to an inlet, which also served as their water source. The horses received no additional feed or minerals during the summer period.

2.2. Experimental design

Within the 30 ha enclosure, a smaller capture enclosure (1 ha) contained a fenced waiting area (50 m^2). Next to the waiting area, a start box (2.5 m^2) and a test arena (10 m in diameter) were constructed out of straw bales (1.2 m $\times$ 1.2 m $\times$ 2.4 m) in two layers, making the height of the walls of the arena 2.4 m (Fig. 1). The set-up enabled the horses to hear, but not see their group mates during the tests. The arena was equipped with a feed container, placed opposite the entrance, with a mixture of alfalfa and the horses' usual winter feed (oat, barley, soybeans, minerals and molasses). The ground in the arena was covered with a thin layer of wood shavings.

2.2.1. Habituation

Prior to the experiment, the stallions were habituated to being isolated and receiving a food reward inside the arena in a gradual, step-wise approach (Table 1). Most horses (75%) passed directly through the three habituation steps, whereas six horses needed more than one trial on one or more of the steps (up to four trials on a step). When a horse met the habituation criteria, it was not exposed further to the test arena until the rest of the horses were habituated. The day prior to a test, all horses were again exposed to the arena, ensuring that all horses fulfilled the habituation criteria and to standardise the time interval between last exposure to the arena and the test.

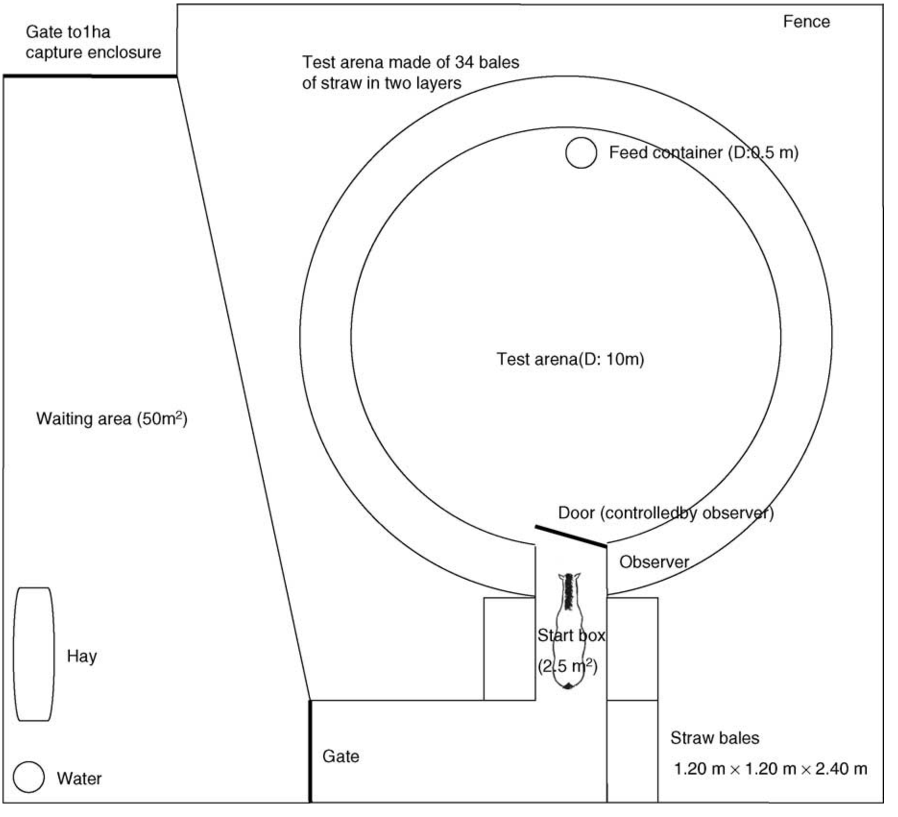

Fig. 1. Diagram of the test arena, start box and waiting area.

2.2.2. *Tests*

The horses were exposed to three 2 min tests in a balanced design where, in addition to the feed container, a visual, an auditory or an olfactory stimulus was presented. Prior to the visual test, a 75 cm high, orange traffic cone with two reflective bands was placed 1 m in front of the feed container, forcing the horse to pass the stimulus in order to approach the food. During the auditory test, a novel sound (white noise, 10–20,000 Hz, 60 dBA) was played from a CD player, hidden behind the feed container. For the olfactory test, eucalyptus oil was applied to the edges and the inside of a similar feed container, which was used for this test only. The horses were tested in two blocks of 12 horses. Between test days, the horses were exposed to the usual arena without novel stimuli (control). The experiment was carried out in August and September 2003, during which the average temperature was approximately 20 °C. Testing on days with heavy rain, wind or other extreme weather conditions was avoided.

The behavioural variables described in Table 2 were recorded using a handheld computer (Workabout, PSION PLC, UK). The observer sat quietly on top of the straw wall next to the start box during all exposures. Subsequently, the data were transferred

Table 1
Habituation procedure

	Training session	Procedure	Note
1.	Identification and 3-step introduction to arena	The horse is caught, identified using ID cards and fitted with a coloured ring in the mane for recognition The handler leads the horse directly to the feed container inside the arena and offers it feed. The horse is led around in the arena once and is offered feed again before returning to visual contact with the other horses. The horse is led to the arena again, the observer closes the door and the same procedure as above is carried out. During the third entry, the horse is allowed to run loose for 2 min, while the handler stands by the feed container. The horse is caught and led to the feed container, if not already there, whereupon it returns to the group	A varying number of horses (2–12) were introduced daily due to their varying willingness to be caught and led
2.	Habituation, step 1	The horse is led to the feed container inside the arena, the door is closed, the handler releases the horse and stands by the feed container for 2 min. The horse is caught and returns to visual contact with the group	A step is passed when the horse stands and eats from the feed container for a period of 30 s during the 2 min exposure. Upon passing a step, the horse carries on to the next step, whereas a failed horse carries on with the same step, until the criterion is reached. A maximum of five trials were allowed per horse per day. On the next day, a horse started on the last passed step
3.	Habituation, step 2	The horse is led to the feed container inside the arena, the door is closed, the handler releases the horse and leaves the arena for 2 min. The handler returns, the horse is caught and returns to visual contact with the group	
4.	Habituation, step 3	The horse is led to the start box in front of the arena while the arena door is closed. The handler releases the horse, the observer opens the door and the horse is free to enter the arena. When inside, the arena door is closed and the horse is left alone inside the arena for 2 min. The handler enters, the horse is caught and returns to the group.	If no eating occurred during the 2 min, the handler led the horse to the feed container and offered it feed before leaving the arena. An observer was always present on top of the arena wall next to the door, habituating the horses to the presence of an observer

Table 2
Ethogram of recorded behaviours

Behaviour	Definition
Duration (s)	
Stand	Standing relaxed, head and neck relaxed
Walk	Walking, energetically or relaxed
Canter/trot	Cantering or trotting
Alert food	Vigilant with elevated neck, with or without tail elevation, head and ears oriented towards food container/novel stimulus, standing or walking
Alert other	As above, but with head and ears oriented in other directions
Investigate food	Neck horizontal or lower, head and ears oriented towards food container/novel stimulus, standing or walking
Investigate other	As above, but with head and ears oriented in other directions, includes touching and manipulating arena walls or ground
Investigate cone	As above, but with head and ears oriented towards the cone
Touch cone	Touching or manipulating the cone
Sniff food	Head within 1 m of food container, neck horizontal or lower, clear exhalations from nostrils
Eat food	Chewing the food; the head may be lifted from the food container for short periods while chewing continues
Frequency	
Eat bout	Eating after pauses of more than 5 s were recorded as a new bout
Nicker	Low amplitude call of long duration
Whinny	High amplitude call of long duration that fluctuates in frequency
Snort	Short powerful exhalations from nostrils
Back	Stepping backwards (minimum two steps)
Flehmen	Head elevated and neck extended, upper lip curled (olfactory investigation)
Paw bout	Striking the ground or air with a forelimb, pawing after pauses of more than 5 s were recorded as a new bout
Defecation	Elimination of faeces
Urination	Elimination of urine

from the PSION to a PC, using the software PSION Manager, Version 1.1. Heart rate (HR) was recorded with Polar Vantage (Polar Electro OY, Kemple, Finland), which consisted of an electrode belt with a built-in transmitter and a wristwatch receiver. Water and exploratory gel were used to optimise the contact between electrode and skin. The HR monitoring equipment was fitted on the horse in the waiting area prior to testing and the receiver stored data from the transmitter (every 5 s). Subsequently, data were downloaded via a Polar Interface to a PC, using the software Polar Precision Performance™ SW 4.

2.2.3. Test procedure

The 12 horses of a particular block were caught and led into the waiting area prior to testing and stayed there until all horses had been tested. Hay and water were available in the area. The rest of the group was kept inside the 1 ha capture enclosure next to the waiting area, ensuring proximity of the entire group during the tests. The test horse was fitted with HR equipment and led to the start box by a handler with whom the horses became familiar during the initial habituation training. After approximately 1 min, the arena door opened, allowing the horse to enter the arena. After the test, the horse was caught by the handler and led back to the waiting area where the HR equipment was removed. After each test, defecations were removed from the arena and extra feed added to the container, if necessary. The test order was the same during all test and control days.

2.3. Data analysis

Latencies, frequencies and time spent on different behaviours were calculated in SAS 8.0 (http://www.sas.com/). Behaviours, which were observed in less than three horses, were excluded from further analysis, i.e. defecation, urination, flehmen and all vocalisations (nicker, whinny and snort). The order in which the horses received the tests was balanced between horses and block and was not considered further in the analysis.

Preliminary tests showed that there was no effect of horse on the initial HR (before the tests), probably due to the similar age, breed and exercise level of the horses, making it unnecessary to correct for individual differences in initial HR. Thus, the analysis was carried out on data for average HR (reflecting the shape of the HR curve; HR_avg) and maximum HR (reflecting the immediate response of a horse towards the test stimulus; HR_max) during the tests. Likewise, preliminary analysis showed that there were no significant differences in behaviour and HR responses between the control days, indicating that there was no carry-over effect from the different test situations and no trend to increasing or decreasing HR during the course of the experiment. Thus, an average for each horse from all control exposures was used as control data in the analysis. The HR data were analysed using Mixed Models in SAS estimating degrees of freedom using Satterthwaite's formula (Littell et al., 1996) with test ($n = 4$), sire ($n = 3$) and their interaction as fixed effects and animal within block within test as a random effect. The model was reduced if terms were not significant ($P > 0.05$). The response variables were HR_avg and HR_max.

Due to skewed distributions and non-constant variances of the behaviour data, these were analysed for effect of test, block and sire separately by Friedman Repeated Measures Analysis of Variance on Ranks, using SigmaStat 3.0 (http://www.spss.com/). All horses, except one horse in the auditory test, approached and ate from the feed container within the test period of 2 min. However, this horse did approach and eat from the container before the handler entered the arena after the end of the test period. It was, therefore, considered unnecessary to treat the latency data as censored values. One horse reared during the olfactory test, which was its first test and the test was stopped due to risk of injury. The horse had previously reacted with this type of behaviour during the initial handling, but did not respond with rearing during the habituation, nor in any of the subsequent tests. However, the Repeated Measures ANOVA on Ranks does not allow for missing data in a balanced design and the horse had to be deleted from the analysis. Thus, this part of the analysis was carried out on $n = 23$ horses.

Correlations between variables within tests and correlations between tests were carried out by Spearman rank-order correlations (coefficients denoted as r_s). Technical problems with the heart rate equipment caused a loss of data in the first block and the correlations between tests were thus based upon smaller sample sizes ($n = 16$, 13 and 11). Due to the low occurrence of many behavioural variables, some related behaviours were grouped (all behaviours related to focussing on 'other' or 'food'; Table 3).

Table 3
Number of animals (out of 23) showing the behaviour in each test and median [25, 75% quartiles]

Behaviour	Control	Visual	Olfactory	Auditory	Chi-square	*P*-value
Stand	9	1	4	3		
(s)	0 [0, 0.4]	0 [0, 0]	0 [0, 0]	0 [0, 0]	6.33	0.097*
Walk	23	23	23	21		
(s)	8 [7, 9]	6 [3, 9]	8 [7, 9]	7 [4, 9]	9.95	0.019*
Canter/trot	3	4	4	4		
(s)	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0]	1.52	0.677
Alert food	1	9	1	13		
(s)	0 [0, 0]	0 [0, 5]	0 [0, 0]	2 [0, 10]	21.25	<0.001**
Alert other	6	8	10	8		
(s)	0 [0, 0]	0 [0, 4]	0 [0, 7]	0 [0, 3]	5.45	0.142
Investigate food	2	6	11	14		
(s)	0 [0, 0]	0 [0, 2]	0 [0, 6]	2 [0, 5]	19.24	<0.001**
Investigate other	13	5	10	7		
(s)	0 [0, 1]	0 [0, 0]	0 [0, 5]	0 [0, 3]	3.79	0.285
Investigate cone		21				
(s)	–	6 [2, 13]	–	–	–	–
Touch cone		3				
(s)	–	0 [0, 0]	–	–	–	–
Sniff food	2	0	10	2		
(s)	0 [0, 0]	0 [0, 0]	0 [0, 6]	0 [0, 0]	20.73	<0.001**
Eat food	23	23	23	22		
(s)	105 [103, 107]	97 [85, 104]	92 [76, 105]	95 [75, 105]	20.85	<0.001**
Eat bout	23	23	23	22		
(freq)	1 [1, 2]	2 [2, 3]	3 [2, 5]	2 [1, 3]	34.75	<0.001**
Back	0	0	0	6		
(freq)	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0.8]	18.00	<0.001**
Paw bout	11	8	10	6		
(freq)	0 [0, 0.6]	0 [0, 1]	0 [0, 2]	0 [0, 1]	1.84	0.606
Latency to enter arena	23	23	23	23		
(s)	3 [2, 5]	3 [2, 5]	2 [2, 5]	2 [2, 4]	5.45	0.142
Latency to eat	23	23	23	22		
(s)	10 [9, 11]	12 [10, 20]	10 [8, 10]	12 [10, 17]	19.51	<0.001**
Focus food[a]	2	22	12	18		
(s)	0 [0, 0]	9 [4, 20]	2 [0, 8]	9 [2, 15]	37.14	<0.001**
Focus other[b]	17	10	18	11		
(s)	1 [0, 2]	0 [0, 7]	5 [1, 11]	0 [0, 5]	8.87	0.031*

Test statistics for the comparison between tests are given in the two last columns.
[a] Time spent focussing on the food/test stimulus (alert food + investigate food + investigate cone).
[b] Time spent focussing on other (alert other + investigate other).

3. Results

3.1. Responses to the different test stimuli

All test stimuli resulted in reduced eating time and increased investigation (investigate food, cone or other features of the arena) compared to the control situation. The number of animals, which showed the different behaviours in the respective test situations, medians (25, 75% quartiles) and the test statistics are shown in Table 3. The latency to eat was

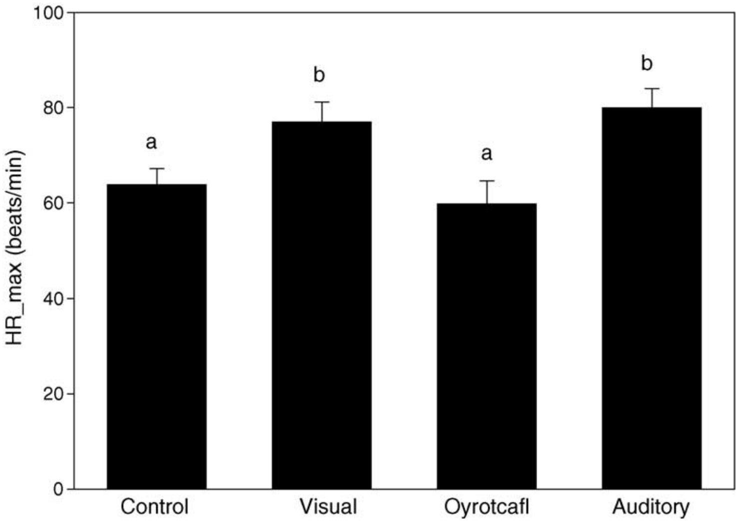

Fig. 2. Maximum heart rate responses (mean ± S.E.) during the tests. Different letters indicate significant difference at $P < 0.05$.

significantly increased for the visual and auditory tests, whereas more disrupted feeding (an increased number of eating bouts) was shown in the olfactory test. Likewise, sniffing the food and focussing on other features in the arena was primarily shown during the olfactory test, whereas the horses spent more time focussing on the food/stimulus in the visual and auditory tests. Backing away from the test stimulus was only shown in the auditory test. In general, very little locomotion was shown by the horses during the tests.

Exposure to the novel visual and auditory stimuli elicited significantly increased HR responses in the horses compared to their response to the control arena, whereas there was no increase in HR to the olfactory stimulus. The maximum HR responses during exposure to the control arena and the three test stimuli are shown in Fig. 2 ($F_{3,65} = 5.73$, $P = 0.002$). The average HR responses to the different test situations gave a similar picture (control: 52.26 ± 2.05, visual: 57.49 ± 2.34, olfactory: 51.02 ± 2.72, auditory: 62.22 ± 2.28; $F_{3,70} = 4.84$, $P = 0.004$).

There were no significant differences between the test days in HR or behavioural response, indicating that the horses did not habituate nor sensitize to being tested. There was no effect of sire in any variables in any tests.

3.2. Correlations between behaviour and heart rate responses

Time spent eating was negatively correlated with all other variables, i.e. the more time a horse spent eating, the less it responded to the test stimulus. Thus, time spent eating was used as a reference variable to study the interrelationship between behaviour and HR responses. There were significant, negative correlations between time spent eating and HR in the visual and the auditory tests (HR_avg: visual: −0.49, $P = 0.032$; auditory: −0.51, $P = 0.022$; HR_max: visual: −0.41, $P = 0.076$; auditory: −0.46, $P = 0.041$), whereas there was no correlation in the control and olfactory tests.

3.3. Correlations between test situations

Horses, which responded with a high HR in the auditory test, also had a high HR in the olfactory and the visual test, i.e. there were significant, positive correlations between HR responses in the olfactory and auditory tests (HR_max: $r_s = 0.66$, $P = 0.013$ and HR_avg: $r_s = 0.72$, $P = 0.005$) and between the visual and auditory tests (HR_max: $r_s = 0.55$, $P = 0.026$ and HR_avg: $r_s = 0.48$, $P = 0.056$). However, there was no correlation in HR between the visual and olfactory tests. Also, there were no significant correlations between the test situations for any behavioural variables.

4. Discussion

4.1. Responses to the different test stimuli

The test stimuli elicited different behavioural responses in the horses and the heart rate increased in response to the visual and auditory stimuli, but not to the olfactory stimulus. Apart from a significantly reduced eating time in all test situations compared to the control situation, it is noteworthy that the behavioural responses to the novel visual and auditory stimuli were similar, whereas the responses towards the novel olfactory stimulus differed. The visual and auditory stimuli elicited increased latencies to eat and more time spent alert towards or investigating the stimulus. During the olfactory test, the horses spent more time sniffing and focussing on other things in the arena and they showed more disrupted feeding. Boissy (1995) suggested that transitions between behaviours can be induced by conflicts between emotional states and motivations and thereby are expressions of fear. In the present study, we found significantly increased heart rate responses to the visual and auditory stimuli, whereas the heart rate did not increase during exposure to the olfactory stimulus. Herskin et al. (2003) also found behavioural but no heart rate responses in cattle towards different types of novel food, including drops of eucalyptus oil added to their usual food. The horses in our study showed very little locomotion activity in all tests; thus, the difference in heart rate responses cannot be attributed to differences in physical activity. The question is why horses only show behavioural and not heart rate responses to an unknown smell and whether this applies to this particular smell only or whether it is adaptive? An increase in heart rate is the body's physiological response to localised danger, preparing the animal for flight. Since smell travels slowly in air, there may be no sense in running away from an unknown smell because the source of the smell may have moved before the animal perceives the smell. However, unknown smells may act to make the animal more vigilant towards the surroundings. In our study, increased vigilance was identified by a significant increase in the number of eating bouts. Vigilance may thus be a measure of fearfulness as suggested by Welp et al. (2004), who studied fear in dairy cattle and found alterations in vigilance according to their degree of fearfulness. Terlouw et al. (1998) investigated responses of cattle to odours of urine and blood from conspecifics and faeces from carnivores and found that the odours induced heightened vigilance, e.g. increased sniffing, but that the odours did not interfere with the expression of feeding motivation. These results correspond to the responses of horses towards a novel smell in the present experiment. On the contrary, it is biologically relevant to be prepared to run away from an unknown sound or visual stimulus and maybe these senses are primarily used for immediate predator detection. Thus, it seems that horses respond to unknown visual and auditory stimuli by both behavioural and heart rate changes, whereas an unknown olfactory stimulus elicits behavioural changes only in terms of increased vigilance towards the surrounding environment. Boissy (1995, 1998) discussed the concepts of fear and anxiety and suggested that the perception of actual danger causes the emotional state fear, whereas potential danger causes the emotional state anxiety. The responses of the horses in the visual and the auditory tests probably reflect the fact that in these tests, the horses were able to localise the stimulus, inducing behaviours to avoid the stimulus ("fear"), whereas the olfactory test induced an expectation of danger ("anxiety"). Further experiments, in which horses are exposed to more biologically relevant smells, e.g. predator odour, are necessary in order to investigate the interrelationship between behavioural and heart rate responses to novel olfactory stimuli.

Backing away from the stimulus was only shown in the auditory test, indicating that this type of behaviour may be an innate response to an unknown sound. However, differences in responses between the test stimuli may not only be attributed to the type of stimulus. Responses may also be linked to the fear-eliciting strength of the test stimulus, which cannot be compared in the present study. The strength of a visual stimulus cannot be equated to the strength of an auditory or olfactory stimulus. However, in the present study, the total eating time was reduced to the same amount in all test situations. This equal eating time indicates a relatively similar strength of the stimuli. Further experiments in which horses are exposed to same type of stimulus but with different fear-eliciting properties would be necessary in order to link specific responses to the activation of different senses. While this may be achieved by studying responses to the same sound at different intensities, it is not so obvious whether a larger visual object is more frightening than a small or a stronger smell more frightening than a weak one.

There were no indications of carry-over effects, which probably relates to the fact that all horses managed to eat within the duration of the tests. The infrequent occurrence of some behaviours, e.g. defecations, vocalisations and the flehmen response, may be a consequence of these behaviours relating to different situations. Defecations and whinnying were shown during the initial habituation, indicating that once habituated to social isolation, these behaviours cease and do not reoccur even when horses are exposed to novelty in a known environment. Our results would also suggest that flehmen behaviour, which is typically shown by stallions when investigating urine, is probably associated more with sexual behaviour rather than the smell of novelty.

4.2. Correlations between behaviour and heart rate responses

The total eating time was found to reflect the reactions of the horses in all test situations in that the more a horse responded to the test stimulus, the greater the reduction in total eating time. The total eating time also reflected the heart rate response in the visual and auditory tests, but not in the control and olfactory tests. The results indicate that an interrelationship between behavioural and heart rate responses exists, given that the heart rate responses are sufficiently strong. This is in agreement with other studies on horses (e.g. Jezierski and Górecka, 1999; Lansade et al., 2003).

4.3. Correlations between test situations

There were no significant correlations in any behavioural variables between the tests, which is most likely due to the stimuli eliciting different and not very strong behavioural responses. Previous studies of consistency of behavioural variables across test situations in horses have shown varying results (e.g. Scolan et al., 1997; Wolff et al., 1997; Visser et al., 2001; Seaman et al., 2002). Discrepancies between studies may relate to the variation in tests to which the horses are exposed, sometimes mixing social and non-social situations. In other species, generalisation of behavioural responses across several different situations has been demonstrated (e.g. mink: Malmkvist and Hansen, 2002; cattle: Boissy and Bouissou, 1995; dogs: Goddard and Beilharz, 1984).

The strong correlation between heart rate responses in the olfactory and auditory tests may reflect the way in which these stimuli were presented as they were probably perceived only as the horses approached the food. This is in contrast to the visual stimulus, which could be easily seen from the start box when the door opened. Considering the small sample sizes, due to loss of heart rate data, as well as the fact that the horses were very similar in their responses, which gives only little variation, it is very likely that even stronger correlations in heart rate responses between different test situations exist. Other studies on horses have also shown correlations in heart rate responses between different tests (Visser et al., 2002). The heart rate correlations across situations indicate that heart rate responses simply reflect a non-differentiated activation of the sympathetic nervous system, whereas the behavioural responses are linked to the type of stimulus.

In conclusion, the responses of the horses to the novel olfactory stimulus differed from those to the visual and auditory stimuli, since the horses showed behavioural responses without a corresponding increase in heart rate towards the novel smell. Heart rate responses correlated between test situations, while the behavioural response was linked to the type of stimulus.

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Predator odour *per se* does not frighten domestic horses

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Abstract

Horses frequently react nervously when passing animal production farms and other places with distinctive smells, leading riders to believe that horses are innately frightened by certain odours. In three experiments, we investigated how horses respond to (1) urine from wolves and lions, (2) blood from slaughtered conspecifics and fur-derived wolf odour, and (3) a sudden auditory stimulus in either presence or absence of fur-derived wolf odour. The experiments were carried out under standardised conditions using a total of 45 naïve, 2-year-old horses. In the first two experiments we found that horses showed significant changes in behaviour (Experiments 1 and 2: increased sniffing; Experiment 2 only: increased vigilance, decreased eating, and more behavioural shifts), but no increase in heart rate compared to controls when exposed to predator odours and conspecific blood in a known test environment. However, the third experiment showed that exposure to a combination of wolf odour and a sudden stimulus (sound of a moving plastic bag) caused significantly increased heart rate responses and a tendency to a longer latency to resume feeding, compared to control horses exposed to the sudden stimulus without the wolf odour. The results indicate that predator odour *per se* does not frighten horses but it may cause an increased level of vigilance. The presence of predator odour may, however, cause an increased heart rate response if horses are presented to an additional fear-eliciting stimulus. This strategy may be adaptive in the wild where equids share habitats with their predators, and have to trade-off time and energy spent on anti-predation responses against time allocated to essential non-defensive activities.

Keywords: Horse; Predator odour; Behaviour; Heart rate; Fear

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1. Introduction

Predation is a strong selective force leading to various adaptations in prey species. Many species have developed specific behaviours to facilitate recognition, avoidance and defence against predators. Such anti-predator behavioural systems are fundamental to survival, and natural selection has favoured mechanisms in prey to detect predators prior to their attack, increasing the probability of escaping or avoiding encounter (Kats and Dill, 1998; Apfelbach et al., 2005; Monclús et al., 2005). Anti-predator defence can involve responses to specific chemical cues that predators produce, and avoidance of predator odours, such as fur, urine, faeces, or anal gland secretions, has been observed in several mammalian species, particularly in rodents (for review see Apfelbach et al., 2005). It has also been shown that odour-induced unconditioned fear in rodents is associated with Hypothalmic-pituitary-adrenal (HPA) and amygdala activation (Dielenberg and McGregor, 2001; Li et al., 2004; Roseboom et al., 2007; Takahashi et al., 2007). Recent studies have suggested that skin and fur-derived predator odours may have a more profound and lasting effect on prey species than those derived from urine or faeces (Apfelbach et al., 2005). Studies on domestic herbivores, such as sheep and cattle, have demonstrated behavioural changes (Terlouw et al., 1998) and reduced feeding (Pfister et al., 1990; Arnould and Signoret, 1993; Arnould et al., 1993) in the presence of dog faeces. Highly distinctive smells, such as that of carnivore faeces, may however interfere with the experience of taste which may in turn cause reduced feeding, without the animal actually being frightened by the odour. Thus, both behavioural and physiological measures should be considered, because the body's immediate physiological reaction to perceived danger is characterised by activation of the sympathetic system (fight or flight response; Guyton and Hall, 1997; Korte, 2001). However, physiological measures have rarely been used in studies of predator recognition in herbivores because the majority of studies have been carried out in the field where such measures are difficult (Apfelbach et al., 2005; Monclús et al., 2005, 2006). In this study we have recorded behavioural reactions in combination with recordings of heart rate, which have been validated as a reliable and non-invasive physiological measure in horses during exposure to a stressor (Visser et al., 2002; Christensen et al., 2005, 2006; McCall et al., 2006).

Ungulates have co-evolved with their predators for millions of years in the wild, and like many other prey species they have evolved anti-predator responses both to actual encounters with predators and to generalised threatening stimuli, such as loud noises and sudden events (Frid and Dill, 2002). Equids typically live in open grasslands with a good view of the surrounding environment and they use vision as a major sensory avenue for detection of predators. Equids are also sensitive to auditory signals of danger, such as sounds of predators, and they have a good sense of hearing (Heffner and Heffner, 1983; MacDonald, 1995). In addition, equids may use olfaction as another modality through which predators can be detected and possibly identified. Chemical signals have been suggested to be involved in several equine processes such as individual identification, co-ordination and spacing of individuals both within and between social groups, mare-foal communication, navigation and orientation, sexual arousal and performance, as well as alarm signalling (Mills and Nankervis, 1999; Waring, 2003). Accordingly, there is a general belief among riders that horses are innately frightened by certain odours. However, we have currently no knowledge of whether horses do find certain odours aversive. A study by Christensen et al. (2005) showed that domestic horses reacted more to unknown visual and auditory stimuli compared to an unknown olfactory stimulus (eucalyptus oil). It is unknown, however, whether this lack in response applies to natural odours as well.

Here we present results from three experiments, in which we investigated how horses respond to (i) urine from wolves and lions, (ii) blood from conspecifics and fur-derived wolf odour, and (iii) a sudden auditory stimulus in either presence or absence of fur-derived wolf odour.

2. Materials and methods

2.1. Animals

We used a total of 45 two-year-old Danish Warmblood horses from a large stud in the three experiments (Experiment 1: 33 stallions; Experiments 2 and 3: 12 mares). All horses were kept on pasture with the dam before weaning (approx. 6 months) and were subsequently kept in large groups of same age and sex; housed in straw-bedded group boxes during the winter and pastured during summer. The horses had received a minimum of handling at the stud, and had been handled only for other research experiments, during which they were habituated to and had similar experiences with the respective test arenas (stallions: Christensen et al., 2007 and mares: Søndergaard, in preparation).

2.2. Test environments

The first experiment was carried out in an outdoor, circular arena (10 m in diameter) constructed out of straw bales (1.2 m × 1.2 m × 2.4 m) in two layers, making the height of the walls of the arena 2.4 m (for details, see Christensen et al., 2007). A feed container, placed opposite the entrance, contained either wood-shavings or sand (according to treatment, see later) and a bucket with a mixture of corn and molasses.

The second and third experiments were carried out in a rectangular, indoor arena (8 m × 10 m) at Research Centre Foulum. The arena was equipped with a feed container, placed opposite the entrance, with corn and molasses.

2.3. Experiment 1: predator urine

In the first experiment, the horses ($n = 33$) were randomly assigned to one of three treatments; either wolf urine, *Canis lupus canadiensis* ($n = 11$), lion urine, *Panthera leo leo* ($n = 11$), or urine from an unknown horse, *Equus caballus* (Danish Warmblod, gelding; $n = 11$) as a control for the reaction to the smell of urine. Urine was collected in Givskud Zoo, Denmark, by collecting sand (wolves) or wood shavings (lions and horse) onto which the animals had urinated. The fresh samples were kept in sealed plastic bags, frozen at $-25\ ^{\circ}$C and were defrosted 24 h before the experiment. Prior to the experiment, the horses were habituated to feeding from the bucket placed inside the feed container with neutral sand (wolf treatment) or wood shavings (lion and horse treatment). On the test day, sand/wood shavings with urine replaced the usual, neutral material in the container so that the odour surrounded the feed bucket without contamination of the feed.

2.4. Experiment 2: blood and fur-derived predator odour

In the second experiment, the horses ($n = 12$) were exposed to blood from a conspecific and fur-derived predator odour. Blood was collected from a slaughtered horse at a commercial slaughterhouse. The donor horse was waiting in isolation (approx. 30 min) at the slaughterhouse while a companion horse was slaughtered, and the donor horse was clearly stressed. The donor blood was mixed with heparin immediately to avoid coagulation and frozen at $-25\ ^{\circ}$C. The blood was removed from the freezer for defrosting 24 h prior to testing. Wolf odour, *Canis lupus canadiensis*, was collected in Givskud Zoo, Denmark, by collection of fur and sand from lying areas and burrow entrances. The samples were collected the day before testing and were kept in hermetically sealed plastic bags. Prior to the experiment, the horses were habituated to feeding from the feed container in the test arena. The experiment ran over 4 days with the first and third day as control tests where we recorded the responses of the horses to the usual arena without odour. On the second day, conspecific blood was applied to the edges and inside of the feed container with no contamination of the feed. On the fourth day, wolf fur was rubbed on the edges and inside of the container and sand with wolf odour was spread around the feed container.

2.5. Experiment 3: predator odour and surprise test

In the third experiment we exposed horses to a sudden auditory stimulus either in presence or absence of fur-derived wolf odour. Odour was collected and stored as in Experiment 2. The experiment was carried out 1 week after Experiment 2, on the same 12 horses. The test stimulus was the sudden sound of a plastic bag, which was pulled 1 m along the sand ground behind the arena wall at a speed of 1 m/s. The horses were allowed to feed for 1 min before the stimulus was applied. For half of the horses, fur-derived wolf odour was applied to the feed container as in Experiment 2 ($n = 6$; sound + odour), whereas the other half of the horses were tested without odour ($n = 6$; sound). The 'sound' group was tested first to avoid odour contamination of the test environment.

In all experiments, fresh odour material was added immediately before each horse entered the arena. Separate containers were used for each treatment, and we were very careful to reduce the risk of odours spreading to the surroundings, e.g. by using lids and plastic bags when transporting containers, as well as by removal of ground material in the immediate vicinity of the containers when shifting between treatments.

2.6. Data quantification and analysis

All tests lasted 2 min, during which behavioural reactions (Table 1) and latency to feed were recorded using a handheld computer (Workabout, PSION PLC, UK). The observer sat quietly on top of the straw wall (Experiment 1) or next to the arena (Experiments 2 and 3), and the horses were previously habituated to the

Table 1
Ethogram of recorded behaviours

Behaviour	Description
Duration	
Eating	Standing by the feed container and chewing food; possibly lifting the head from the container while chewing continues. If chewing was interrupted for more than 2 s, the interfering behaviour was recorded and resumed chewing was recorded as a new bout.
Sniffing	Standing within 1 m of feed container with lowered head oriented towards feed container; repeated and clear exhalations.
Alert (towards container)	Horse is alert with elevated neck, with or without tail elevation, head and ears oriented towards feed container.
Focus other	The horse focuses on other stimuli, e.g. sounds from outside.
Flight (Experiment 3)	The horse jumps away from the feed container in a sudden movement, typically followed by trotting/galloping, alertness and possibly snorting. The duration of the flight responses lasts until the horse resumes chewing (which always happens before the horse returns to the feed container). Flight reactions were shown only in Experiment 3 after exposure to the sudden stimulus.
Frequency	
Defecation	Elimination of faeces.
Snort	Short powerful exhalation from nostrils.
Paw bout	Striking the ground or air with forelimb; pawing after pauses of more than 5 s was recorded as a new bout.
Flehmen	Head elevated and neck extended, upper lip curled (olfactory investigation); flehmen after pauses of more than 5 s was recorded as a new bout.

presence of the observer. Heart rate (HR) was recorded with Polar s810i (Polar Electro OY, Kempele, Finland), which consisted of an electrode belt with a built-in transmitter and a wristwatch receiver. Water and gel were used to optimise the contact between electrode and skin. The HR monitoring equipment was fitted on the horse in the waiting area prior to testing, and the receiver stored data from the transmitter (every 5 s). Subsequently, data were downloaded via a Polar Interface to a PC, using the software Polar Precision Performance^{TM} SW 4. The HR recordings started 5 min prior to testing, but for the analysis we used data only from the 2 min test time where the horse was moving freely inside the test arena. The average HR (HR_avg) and the maximum HR (HR_max) during the 2 min test were determined for each horse.

Behavioural and heart rate data (HR_max and HR_avg) were analysed for effect of treatment by One Way Analysis of Variance (ANOVA; SigmaStat 3.0, http://www.systat.com). All horses returned to the food within the test time and thus latencies could also be analysed using ANOVA. A significance level of $P < 0.05$ was used throughout.

3. Results

3.1. Experiment 1: predator urine

Horses that were exposed to urine from wolves and lions spent significantly more time sniffing compared to those exposed to horse urine (seconds, mean ± S.E.: Lion: 19.6 ± 4.4, Wolf: 16.5 ± 4.8, Horse: 1.2 ± 0.6; $F_{2,30} = 6.83$, $P = 0.004$). Also, we found a tendency towards an increased number of eating bouts in the wolf and lion group (freq., mean ± S.E.: Lion: 5.2 ± 0.4, Wolf: 4.8 ± 0.4, Horse: 3.9 ± 0.3; $F_{2,30} = 2.94$, $P = 0.068$). However, there was no significant effect on any other behavioural variables (e.g. latency to eat: $F_{2,30} = 0.29$, $P = 0.747$; total eating duration: $F_{2,30} = 2.05$, $P = 0.146$; focus other: $F_{2,30} = 1.91$, $P = 0.166$), neither were there any differences in heart rate responses between the treatment groups (HR_avg: $F_{2,30} = 0.62$, $P = 0.546$; HR_max: $F_{2,30} = 0.21$, $P = 0.811$).

3.2. Experiment 2: blood and fur-derived predator odour

The results from Experiment 2 are summarised in Table 2. When exposed to blood from conspecifics and fur-derived predator odour the horses showed significant behavioural changes in terms of increased sniffing and vigilance (“focus other”, Table 2), decreased eating, and an increased number of behavioural shifts, compared to control days. However, there were no significant increases in heart rate (Table 2).

Table 2
Experiment 2: behaviour and heart rate given as mean ± S.E.M.

	Day 1 Control	Day 2 Blood	Day 3 Control	Day 4 Wolf	*F*-value	*P*-value
Eating (s)	85.9 ± 5.4	67.0 ± 5.1	86.3 ± 4.7	56.0 ± 5.0	18.88	<0.001
Sniffing (s)	0 ± 0.0	14.9 ± 3.8	0 ± 0.0	37.2 ± 5.8	31.00	<0.001
Focus other (s)	4.1 ± 1.0	9.9 ± 3.7	1.8 ± 0.6	4.0 ± 1.2	3.56	0.025
Eating bouts (freq.)	6.6 ± 0.7	9.8 ± 1.0	6.3 ± 0.6	8.0 ± 0.7	9.29	<0.001
Sniffing bouts (freq.)	0 ± 0.0	4.6 ± 1.1	0 ± 0.0	5.3 ± 0.9	20.66	<0.001
Snort (freq.)	0 ± 0.0	0.7 ± 0.3	0 ± 0.0	0.9 ± 0.5	2.64	0.065
HR_max (bpm)	57.4 ± 1.6	60.3 ± 4.2	57.8 ± 1.6	67.4 ± 5.0	1.81	0.166
HR_avg (bpm)	49.0 ± 1.0	50.6 ± 1.4	49.1 ± 0.8	52.5 ± 2.1	1.90	0.150

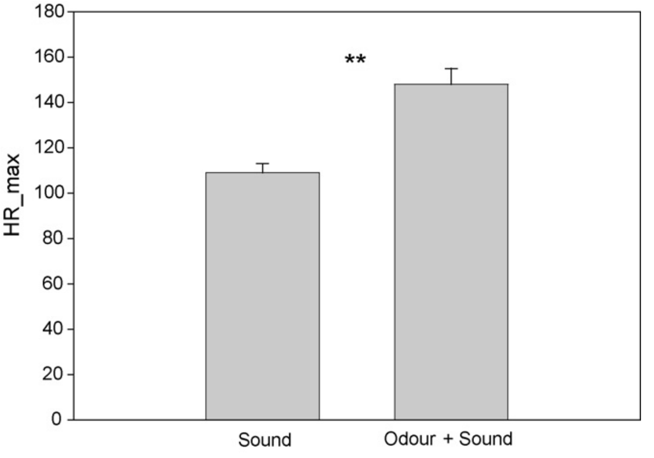

Fig. 1. Experiment 3: Heart rate responses upon presentation of a sudden stimulus.

3.3. Experiment 3: predator odour and surprise test

A flight response was shown by all horses in both treatment groups after exposure to the sudden auditory stimulus. However, we found that horses which were exposed to the sound in combination with predator odour showed significantly increased heart rate responses (Fig. 1, $F_{1,8} = 23.69$, $P = 0.001$), and a tendency towards a longer latency to return to the food after the stimulus exposure (seconds, mean ± S.E.: Odour + Sound: 13.3 ± 2.36, Sound: 7.67 ± 1.41; $F_{1,10} = 4.25$, $P = 0.066$).

4. Discussion

Our results demonstrate that domestic horses show only minor behavioural reactions to the odour of predator urine in a known environment, and some investigative behaviour (e.g. increased sniffing and focussing on other stimuli), but no increase in heart rate, to fur-derived wolf odour and blood from a slaughtered conspecific. However, the introduction of additional cues of danger, i.e. a sudden auditory stimulus, caused horses in the presence of predator odour to show stronger flight reactions, compared to control horses without the odour. Although the selection pressure for predator recognition has inevitably been relaxed through domestication, the latter result indicates that innate responses towards predators may not be lost. This result is in accordance with studies on sheep, showing that anti-predator strategies that evolved in wild sheep persist in domestic animals, even in the absence of natural predators (Byers, 1997). Similarly, several studies suggest that domestic horses express the same movement and social behaviours as wild horses if provided with an appropriate physical and social environment in which to show their full behavioural repertoire (Christensen et al., 2002; Waring, 2003; Boyd and Keiper, 2005; Feh, 2005). Dwyer (2004) suggests that although the threshold for expression of some behaviours (e.g. fear responses) may be elevated in domestic animals, there is no evidence that these behaviours are not expressed once the threshold has been reached. It is currently unknown whether a similar increase in heart rate could be obtained with other novel odours (i.e. non-predator), and this question needs further study.

The results of our urine experiment correspond to those of Novallie et al. (1982) who investigated whether felid urine could reduce feeding by two antelope species (*Raphicerus melanotis* and *Sylvicapra gimmia*). Both species of antelope sniffed more frequently at predator rather than at control urine (from sheep and rats), but there was no effect of urine type on time spent feeding and frequency of alert postures. Such responses may be adaptive for large ungulates living in habitats with low vegetation and a good view of the surrounding environment, which share habitats with their predators and must continue to forage, despite many remote cues to predation risk. In contrast, a few studies on deer (Sullivan et al., 1985; Swihart et al., 1991) and many studies on rodents (e.g. Sullivan et al., 1988; Nolte et al., 1994; Bean et al., 1997; Rosell, 2001) have reported decreased feeding rates upon presentation of predator urine. This difference is likely to be caused by these species occupying different types of habitats, where vegetation hampers visual scanning of the environment. Olfactory cues may thus be more important for animals living in physically complex habitats, or for nocturnal animals. Powell and Banks (2004) suggest, however, that the general importance of predator odours in influencing the foraging activity of small mammalian prey may have been overestimated. They conclude from their study that any avoidance of predator odours may be transient or subtle rather than strong and consistent for free-living prey, which must continue to forage with a constant background of predator odours.

In our second experiment, we found a change in behaviour when test horses were exposed to fur-derived wolf odour and blood from a conspecific, but there were no physiological indications that the animals were frightened in presence of the odours. The blood used in the present experiment was from a stressed conspecific, which had been transported to a commercial slaughterhouse with another horse, and it was waiting in isolation while the other horse was slaughtered. Terlouw et al. (1998) reported that when cattle were exposed to blood from commercially slaughtered conspecifics they showed an increase in sniffing and in ‘‘stretched locomotion’’, which was suggested to express perception of an odour indicating danger. They further suggest that the response may be caused by presence of alarm odours in the blood. Boissy et al. (1998) found that heifers showed avoidance and other fright reactions when confronted with the odour of urine from stressed conspecifics, suggesting that heifers are sensitive to conspecific alarm pheromones. It has been argued that for prey species that live alongside their predators, responses to alarm pheromones are more adaptive than responses to cues of predator presence, because prey is really in danger only when the predators are hunting, as indicated by release of alarm pheromones from conspecifics (Wyatt, 2003). Although blood from a stressed conspecific caused behavioural changes in our study, the physiological data do not support a perception of danger in the test horses.

The results of our final experiment, that horses reacted more when presented to additional cues of danger, is likely to be related to fear reactions being energetically expensive and thus more cues, e.g. auditory or visual, of an approaching predator should be present in order to evoke fear reactions in these prey animals. In accordance with our results, Borowski (1998) showed that in root voles the distance maintained from sources of predator odour was not greater than that from non-predator odour, and suggested that the reaction of root voles to the odour of weasel in the home range is not to escape from the range but rather to reduce the probability of an encounter with the predator. This strategy is probably also evident in equids in that predator odours *per se* do not evoke physiological signs of fear (i.e. preparing the animal for the fight or flight response), but rather act to increase vigilance so that the animal responds more readily than it would otherwise, if presented with additional cues of danger. Such a strategy would be adaptive in the wild where equids share habitats with their predators, and have to trade-off time and energy spent on anti-predation responses against time allocated to essential non-defensive activities such as feeding and reproduction (Lima and Dill, 1990).

Natural and artificially produced predator odours are commonly used in an attempt to reduce feeding damage by ungulates in plantations as well as to keep game away from roads, but such initiatives have been of varying success (Apfelbach et al., 2005). Wagner and Nolte (2001) tested 20 deer repellents and found that those eliciting fear were the most effective. The results of our study, using a combination of behavioural and physiological measures, support the view that large prey species, such as ungulates, which live in open grasslands and typically share these habitats with their predators, may not be innately frightened by the odours of predators. The odours of predators probably act merely to increase vigilance, and the animals show fear reactions only if additional cues of danger are present. Griffin (2001) suggests that prey animals on African plains are able to determine the likelihood of imminent attack by monitoring predator behaviour. It is clearly adaptive for a prey animal to respond only to real threats rather than wasting energy and foraging opportunity in unnecessary flight (Kats and Dill, 1998; Dwyer, 2004).

Although some prey species may recognise a potential predator odour innately, it is very likely that prior experience facilitates recognition. Dwyer (2004) suggests that, in sheep, the behavioural response to predators (vigilance, flight) is innate, but the stimuli that elicit this behavioural pattern may have a learned component. Likewise, horses are well able to form associations between events and readily learn to associate unpleasant experiences with places, people or other stimuli (Nicol, 2002, 2005), and thus they may easily learn to associate a certain odour with danger. We conclude that predator odour *per se* did not frighten predator-naïve domestic horses in the present experiment. Domestic riding horses that react fearfully to certain odours may have either learned to associate the smell with danger, or may be reacting to other stimuli in their environment.

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Research

Validation of a fear test in sport horses using infrared thermography

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ABSTRACT

The aims of the present study were to assess feasibility and validity of a fear test in adult sport horses and to investigate whether the exposure to a fearful stimulus induces a change in eye temperature. Fifty horses, aged 14 ± 6 years, of different breed and gender, entered the study. For each horse, a caretaker was asked to fill in a validated temperament questionnaire. A novel object fear test (NOT), has been selected from literature to examine fearfulness. Temperature of the lacrimal caruncle was measured before the test and after the test on 22 horses, representative of the whole sample. To assess discriminant validity of the NOT, 3 human-animal relationship tests were performed on the same horses. Data were analyzed with descriptive, nonparametric, and multivariate statistic methods. No significant differences were found between females and geldings for any of the measured variables. Horses that were described by caretakers as more prone to panic, vigilant, excitable, skittish, and nervous ($P < 0.001$) needed significantly longer time to reapproach the novel object ($P < 0.01$). Eye temperature was significantly higher after the NOT compared to basal ($P < 0.01$), with subjects who did not reapproach the novel object tending to present larger increases ($P < 0.10$). Horses showing more fear-related responses to the NOT did not show more negative reactions to humans during the human-animal tests. These results suggest that, to some extent, the NOT predicts horses' behavior in real on-farm situations. Our findings reject the hypothesis that reactivity to humans and general fearfulness belong to the same basic feature of temperament. Importantly, infrared thermography proved to be useful in assessing physiological reactions of fear in horses.

Introduction

Fear in domestic animals has been defined by Boissy (1998) as a reaction of the perception of actual danger. Fear responses are characterized by behavioral and physiological modifications (Forkman et al., 2007): active defense (attack, menace), active flight (hiding, escape), and passive avoidance (freezing) are some of the behaviors that are frequently related to an underlying emotion of fear in animals (Erhard and Mendl, 1999). When experiencing fear, cardiovascular changes occur in different parts of the body with the ultimate effect of increasing perfusion pressure and redirecting blood flow to the central nervous system and skeletal musculature. Sport horses may be subject to different fearful events, for example, being transported and competing in different environments with novel stimuli and sounds (McGreevy and McLean, 2010), being approached by unfamiliar people, or undergoing many handling and management procedures. Horses, as prey animals, have a tendency to escape from frightening stimuli and may show flight reactions which can be dangerous for both the horse and the man (Christensen et al., 2008, 2005; McGreevy and McLean, 2010). Keeling (1999) demonstrated that in equitation sports many serious human injuries occur as a result of unexpected horse fear reactions. Because owners often misunderstand the reason for the development of such behaviors in their horses, attempts at correcting them often involve suppression- or punishment-based approaches (Hothersall and Casey, 2012). Although repeated subjugation of undesirable fear responses may ultimately appear to solve the overt behavioral reaction, this method can cause short- or long-term stress (McGreevy and McLean, 2010) and can worsen the problem or lead to the development of alternative avoidance strategies such as abnormal behaviors (Hothersall and Casey, 2012). Besides possible problems caused by inappropriate human reactions to fear

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displays, a long-term negative emotional state related to fear can per se cause chronic stress and reduced welfare (Dantzer and Mormede, 1983; Désiré et al., 2006; Minch et al., 2008; Willner et al., 1992).

Because of the aforementioned reasons, it is blatantly obvious that fear in horses plays an important role in their welfare, and thus, it is important that it is recognized and assessed accordingly. Various fear tests have been used to determine temperament characteristics in horses, such as novel object (e.g., Anderson et al., 1999; Christensen et al., 2008, 2005; Seaman et al., 2002; Visser et al., 2003b, 2002; Wolff et al., 1997), novel arena (e.g., Le Scolan et al., 1997; Seaman et al., 2002; Wolff et al., 1997), and restraint and human fear tests (e.g., Le Scolan et al., 1997; Visser et al., 2003b, 2001; Wolff et al., 1997). The novel object test (NOT) is an experimental situation in which the animal is exposed to an unknown stimulus to provoke a fear reaction. Although it is not possible to attribute a given measure to any single emotion, time to approach the new stimulus appears to be one of the most appropriate indicators of fearfulness (Górecka-Bruzda et al., 2011; Wolff et al., 1997). Feasibility under field conditions and ease and duration of fear tests are important characteristics for them to be applied as well as reliability and validity (Górecka-Bruzda et al., 2011). Validity means the degree to which a test measures what it purports to measure (Martin and Bateson, 1993; Weiblinger et al., 2006). Predictive validity measures the ability of an indicator to predict some later criterion (Cronbach and Meehl, 1955). To assess predictive validity of fear tests, different studies investigated their correlation with surveys via questionnaires which aimed to detect those characteristics of temperament in horses that influence their habitual behavior (e.g., Anderson et al., 1999; Le Scolan et al., 1997; Momozawa et al., 2007, 2003; Morris et al., 2002a, 2002b). Respondents were generally caretakers or riding teachers who were familiar with horses; thus, their responses were based on long-term observation and were not influenced by a temporary change in equine behavior, which may occur in behavioral tests (Momozawa et al., 2005).

Discriminant validity analyzes the divergence between measures of conceptually unrelated concepts, for instance, fear and human-animal relationship, and has seldom been evaluated for fear tests (Górecka-Bruzda et al., 2011; Visser et al., 2003b). Convergent validity regards the relationships between independent measures of the same conceptually related construct (Weiblinger et al., 2006). Assessment of convergent validity of fear tests usually considers whether their outcome is related to physiological changes due to fear. Some of the most frequently used physiological indicators are heart rate (e.g., Christensen et al., 2008; Momozawa et al., 2003), heart rate variability (e.g., Rietmann et al., 2004; Stewart et al., 2008c; Visser et al., 2002; von Borell et al., 2007), cortisol concentration (e.g., Anderson et al., 1999; Cook et al., 2001; Flauger et al., 2010; Stewart et al., 2008a), and infrared thermography (IRT). Infrared thermography can be used to detect changes in peripheral blood flow (which causes changes in body heat) as a response to fear-induced stress. Studies in different animal species have revealed that after a stressing event the small areas around the posterior border of the eyelid and the caruncula lacrimalis change temperature. This area has rich capillary beds innervated by the sympathetic system (e.g., McGreevy et al., 2012; Stewart et al., 2009, 2007) and thus represents an ideal place for measuring local changes in blood flow resulting from tuning of the autonomic nervous system. Stewart et al. (2007) measured an increase in eye temperature in cows after intramuscular injection of adrenocorticotropic hormone, corticotropin-releasing hormone, and epinephrine. Research carried out on different species correlated increased eye temperature with cortisol concentrations in response to pain (Stewart et al., 2008b, 2008c), stress (Ludwig et al., 2007; Stewart et al., 2007; Valera et al., 2012), and fear (Stewart et al., 2008a). In a study on horses undergoing stressful situations, Valera et al. (2012) found that the eye temperature increased as a consequence of stress. Similar results were found by Hall et al. (2010) who found a higher eye temperature in horses lunged with the Pessoa training aid (held responsible for increasing the stress during training) than horses without. Bartolomé et al. (2013) were able to demonstrate a correlation between an increase in heart rate and eye temperature after jumping competitions. Cook et al. (2001) investigated the underlying causes of increase in eye temperature in horses and found that it was correlated to activation of the hypothalamic–pituitary–adrenal axis.

To our knowledge, changes in superficial temperature during fear exposure have never been studied in horses. This study aims to assess the feasibility and predictive, convergent, and discriminant validity of a fear test in adult sport horses and investigates whether the exposure to a fearful stimulus induces a thermographic change in eye temperature.

Methods

This study was conducted in agreement with ISAE ethical guidelines (ISAE Ethics Committee, 2002) on adult nonpregnant horses, and no animals underwent more than the minimal distress. In addition, if horses displayed any hyper-reactive behavior that could compromise the horse or the assessor's safety, the test was immediately ended and the observer left the box (this was recorded as a result).

Animals

Experiments took place from January to May 2013 at 6 different riding centers in Northern Italy. A total of 50 adult riding horses (mean age, 14 $\pm$ 6 years) of different sex (30 geldings, 16 mares, 4 stallions) were used in the study. Horse breeds were variously distributed and comprised warmblood horses, draft horses, and thoroughbreds. All horses were stabled in single boxes with daily access to group paddocks for 1-10 hours. Straw bedding was used in 2 centers, whereas horses were kept on wood shavings in the remaining 3 centers. Horses were fed 3 times a day with hay and concentrated industrial feed depending on the type of activity they carried out. Water was provided ad libitum.

Questionnaire survey

Six caretakers (1 per riding center) completed the questionnaires for the 50 tested horses; the number of questionnaires filled in per caretaker varied from 6 to 10. The questionnaire was developed and validated by Momozawa et al. (2005) and contained 20 questions regarding horse temperament (Table 1). The responses were ranked on a scale from 1 to 9, with 1 being the lowest rank for each item. Two animal welfare experts translated the questionnaire into Italian; the mother tongue of both translators was Italian and their level of English was advanced. In a second round, the authors discussed and refined some of the items, which they felt might be difficult to interpret.

Behavioral tests

Four behavior tests were chosen and are described in sections from "Fear test (NOT)" to "Forced human approach test." All tests were conducted on the same day and in the same housing conditions. Horses were tested at least 1 hour before work and between meals to avoid possible distractions and confounding food motivation. A map of the facility was drawn before testing the horses to facilitate the randomization of the testing order. To avoid

Table 1
Questionnaire items

Item	Description (this horse tends to …)	1	9
Nervousness	Become nervous about insects, noises, etc.	Calm	Nervous
Concentration	Be trainable and undisturbed by the environment	Poor	Excellent
Self-reliance	Be at ease if left alone away from the herd	Restless	At ease
Trainability	Be trained easily and promptly	Poor	Excellent
Excitability	Get excited easily	Not excitable	Excitable
Friendliness toward people	Be never aggressive or fearful	Unfriendly	Friendly
Curiosity	Be interested in novel objects and approach them	Rarely	Frequently
Memory	Memorize what it learned or was trained	Poor	Excellent
Panic	Get excited to an abnormal extent	Never	Frequently
Cooperation	Be cooperative with a caretaker when handled	Never	Always
Inconsistent	Emotionality be unpredictable from day to day	Consistent	Inconsistent
Stubbornness	Be obstinate once it resists a command	Obedient	Stubborn
Docility	Be docile in general	Active	Docile
Vigilance	Be vigilant about surroundings	Never	Always
Perseverance	Be patient with various stimuli	Impatient	Patient
Friendliness toward horses	Interact with other horses in a friendly manner	Unfriendly	Friendly
Competitiveness	Be dominant in antagonistic encounters with other horses	Subordinate	Dominant
Skittishness	Get surprised easily	Not skittish	Skittish
Timidity	Be timid in a novel environment	Audacious	Timid
Trailer	Entrance go easily through the trailer door	Rarely	Always

Adapted from Momozawa et al. (2005).

habituation, horses kept in adjacent boxes were not tested consecutively. The test order was designed to firstly measure reactivity to a human followed by the fear test. Two female experimenters (aged 24-28 yrs), experienced in the field of animal welfare, conducted the tests. The first assessor performed the tests, whereas the second assessor scored the reactions of the horse to the different tests from a distance and without interfering with the test performance. To maintain consistency, the assessors always wore the same type and color of clothing at all the riding centers, including appropriate safety clothing (e.g., accident prevention shoes) to reduce risk of injuries. Preventive safety measures always included making sure that there were no obvious physical hazards in the environment. Before the first assessment, both assessors familiarized themselves with the tests by researching relevant scientific literature and performing preliminary practical trials with a trainer familiar with the experimental procedures.

Fear test (NOT)

For the fear test (NOT), an object which was not familiar to the horses was used. The procedure was derived and adapted from the work conducted by Górecka-Bruzda et al. (2011). A green, 1.5 L plastic bottle, filled with small stones and attached by a 4-m cord, was placed at the box entrance, and the cord was hung over the box door to keep the bottle at a height of approximately 1.5 m. In the original test, the plastic container was placed next to the feeding bucket. The latency time to explore (sniffing, touching) the novel object was measured (first latency). When the horse approached, or after 300 seconds, the experimenter released the cord allowing the bottle to drop, thus emitting an unexpected, muffled noise. Latency to reapproach the bottle was then measured (second latency). The test was considered finished when the horse reapproached the bottle or after 300 seconds.

Avoidance distance test

At a distance of 2 m from the door of the horse box, the observer waited until the horse's attention was directed toward them and then slowly began to approach the horse at approximately 1 step per second. The observer never made direct eye contact with the horse; conversely, they kept their eyes focused on the muzzle and an arm raised in front of them at an angle of 45°, with the palm facing downward. The test terminated at any point when the horse showed an avoidance reaction (taking steps away from the observer or turning of the head). In such instances, a score of 0 was assigned. If the horse remained stationary and accepted being touched by the observer, a score of 1 was recorded.

Voluntary animal approach test

The assessor stood in front of the horse box with their body at an angle of approximately 45° and placed one hand on the box door while remaining motionless for 20 seconds. The latency until the horse approached and touched the hand was measured. If the horse did not approach the experimenter, a score of "more than 20 seconds" was given. The behavior of the horse was also recorded on a 3-point scale; 0 was given when the horse was aggressive (ears back, trying to kick, trying to bite, rearing), 1 when the horse showed no interest in human presence, and 2 when the horse was interested and friendly (sniffing, turning the head toward the observer, approaching).

Forced human approach test

Once the horse had touched the experimenter or after a period of 20 seconds had passed with no signs of aggression shown, the assessor entered the box and approached the horse. Remaining approximately 0.5 m from the animal, the assessor placed a hand on the horse's neck and walked slowly to the rear of the horse maintaining contact with the horse. The behavior toward the observer was recorded on a 3-point scale; 0 was given when the horse did not allow the observer to touch them, 1 when the horse allowed the observer to touch them but then tried to move away, and 2 when the horse allowed the touch.

Infrared thermography

On a group of subjects (N = 22) from 3 riding centers and representative of the whole sample, eye temperature before the test and after the test was evaluated. This group was composed of horses of different breeds and sexes (10 mares, 4 stallions, and 8 geldings), aged between 3 and 27 years (mean = 13 years). An infrared camera (NEC Avio TVS500; Nippon Avionics Co., Ltd, Tokyo, Japan) with standard optic system was used to record the temperature (°C) of the lacrimal caruncle. The thermographic infrared images were captured by a certified technician (E.H.).

Lacrimal caruncle was chosen as target area on the basis of information derived from the studies by Bartolomé et al., 2013;

Cook et al., 2001; McGreevy et al., 2012; Stewart et al., 2009 and because its temperature is not influenced by the presence of hair. In our study, it was not possible to regulate room temperature and humidity but they were relatively stable across all situations (minimum = 19.30°C, maximum = 21.00°C; mean = 19.73°C).

To optimize the accuracy of the thermographic image and to reduce sources of noise, before every work session the same image of a Lambert surface was taken to define the radiance emission and to nullify the effect of surface reflections on tested animals (Mallick et al., 2005). Only images perfectly on focus were used. To determine the caruncle temperature, Grayess IRT Analyzer 6.0 software (Grayess Inc., Bradenton, FL; Grayess, 2007) was used, and the maximum temperature (°C) within a circular area traced around the area was measured. This maximum value was used for subsequent analysis.

All the horses undergoing this procedure were accustomed to being restrained with head collar and a loose rope. To collect sharp images without using potentially stressful restraint methods, all the thermographic images were taken while the subject was gently restrained by holding the lead rope fixed to the head collar, allowing enough movement away from the approaching observer should the horse want to retreat. All horses were scanned from the same angle (90°) and distance (approximately 0.5 m) inside their own box. Five images were taken before and 5 images immediately after the test. All thermographic data were analyzed with Grayess IRT Analyzer software.

Statistics

Data were entered into Microsoft Excel (Microsoft Corporation, 2010) and then analyzed with SPSS statistical package (IBM SPSS Statistic 21). Descriptive statistics including relative proportions, minimum and maximum values, median, mean, and standard deviations were calculated. The data were tested for normality using the Kolmogorov-Smirnov test. The Mann-Whitney *U* test was used to verify if the sex of horses affected the questionnaire scores or the test outcomes. Differences were considered to be statistically significant if $P \leq 0.05$. Factor analysis was performed using the principle factor method for factor extraction to evaluate any relationship between questionnaire items. A correlation matrix with varimax rotation was used, and factor scores were calculated for horses when the factor's Eigen value was >1. A two-step cluster analysis with automatic determination of the number of clusters was performed on questionnaire items relating to "fearfulness or anxiety" (as determined by factor analysis) and outcomes of the NOT to identify groups of horses that are similar to each other for the considered variables. The two-step clustering algorithm handles both continuous and categorical variables, continuous variables are z-standardized by default to make them comparable. The Mann-Whitney *U* test was used to verify if the horses assigned to different clusters significantly differed for the considered variables. A match-paired Wilcoxon test was used to compare thermographic data before and after the test and analysis of variance (ANOVA) was used to compare thermographic variations between horses that did or did not approach the novel object. The Kruskal-Wallis ANOVA test was used to evaluate if the horses showing more intense fear reactions to the NOT also showed higher reactivity to the human-animal tests.

Results and discussion

The startling novel object test chosen as a reference (Górecka-Bruzda et al., 2011) and further refined in this study was selected because it is used in horses for measuring fear, and its validity has been confirmed in a previous scientific work, although only in coldblood horses. It was also promising in terms of feasibility as it is of simple execution; it can be performed in the horse home box and its lead time is relatively short. However, before considering implementation in an on-farm welfare assessment protocol, refinement of the original test was deemed necessary to avoid possible conflicting motivations initially caused by proximity of the novel object to the food bucket. Our results revealed that the NOT was feasible under field conditions in sport horses. No safety issues were encountered; no tests had to be interrupted because of dangerous reactions of horses, and all owners showed good acceptability of the procedure adopted to test the animals. Total time required to perform the test revealed substantial individual variability, ranging from 0 to 600 seconds (mean, 141 ± 177 seconds); mean latency time to first approach the bottle was 23 ± 45 seconds, and horses needed 27 ± 34 seconds to reapproach the bottle after it had been dropped in the box.

Table 2
Descriptive results of horse scores on the different questionnaire items

Item	Minimum-maximum	Median	SD
Nervousness	1-8	4	2
Concentration	2-9	7	2
Self-reliance	3-9	7	2
Trainability	2-9	7	2
Excitability	1-5	7	2
Friendliness toward people	2-9	8	2
Curiosity	1-9	7	2
Memory	3-9	7	2
Panic	1-9	4	2
Cooperation	5-9	8	1
Inconsistent emotionality	1-9	3	2
Stubbornness	1-9	3	2
Docility	3-9	8	2
Vigilance	1-9	5	3
Perseverance	1-9	7	2
Friendliness toward horses	1-9	7	2
Competitiveness	1-9	6	2
Skittishness	1-9	4	2
Timidity	1-8	4	2
Trailer	4-9	8	1

SD, standard deviation.

Table 2 reports the scores (minimum, maximum, median, and standard deviation) of each questionnaire item. Horses were prevalently described by their caretakers as trainable, friendly toward people, with a good memory, cooperative, docile, and were easy to get onto the trailer, as attested by high scores in these descriptors.

No significant differences were found in questionnaire scores or NOT results between females and geldings (Mann-Whitney *U*, $P > 0.05$). Stallions were not compared to the other sexes because of their limited number ($N = 4$). Several authors investigated the effect of sex on personality traits of horses of different breeds and ages, using diverse methods and coming to different conclusions (Bartolomé et al., 2013; Kędzierski and Janczarek, 2009; Maros et al., 2010; Momozawa et al., 2007; Rietmann et al., 2004; Seaman et al., 2002; Visser et al., 2002; Wolff et al., 1997). Our results are consistent with those of Rietmann et al., (2004) who found that geldings did not differ from mares in any investigated measure of mental stress during training (heart rate, heart rate variability, and stress-related behavior) and Seaman et al. (2002), who found no significant differences between the factor scores of mares and geldings subjected to 3 different behavioral tests (an arena test, an unknown person test, and a NOT). However, our findings are in contrast with studies by Momozawa et al. (2007) and Maros et al. (2010) who found differences between sexes in the response to a behavioral isolation test (Momozawa et al., 2007) and in the behavior after a response to familiar humans (Maros et al., 2010).

Table 3
Outcomes of the PCA of the recorded questionnaire items

Factor	Eigen value	Percentage variance explained	Cumulative variance explained
PC1	6.264	31.319	31.319
PC2	2.734	13.671	44.990
PC3	2.047	10.234	55.224
PC4	1.338	6.688	61.912

Item	PC1	PC2	PC3	PC4
Nervousness	**−0.706**	0.007	0.170	0.016
Concentration	**0.641**	0.403	−0.238	−0.303
Self-reliance	**0.627**	0.238	−0.243	0.249
Trainability	**0.544**	0.547	0.305	0.029
Excitability	**−0.702**	0.428	−0.023	0.287
Friendliness toward people	**0.510**	−0.418	0.072	0.504
Curiosity	0.263	−0.188	**−0.688**	0.164
Memory	0.457	**0.564**	−0.098	−0.150
Panic	**−0.717**	0.262	−0.081	0.243
Cooperation	**0.558**	0.070	0.340	0.304
Inconsistent emotionality	**−0.752**	−0.168	−0.023	0.034
Stubbornness	−0.451	−0.428	**−0.628**	−0.155
Docility	**0.594**	−0.182	0.315	0.170
Vigilance	−0.390	**0.599**	0.192	0.209
Perseverance	**0.631**	0.129	0.213	−0.056
Friendliness toward horses	0.107	**−0.735**	0.252	0.068
Competitiveness	−0.187	0.301	−0.356	**0.571**
Skittishness	**−0.798**	0.145	0.234	0.194
Timidity	−0.463	−0.227	**0.613**	−0.103
Trailer	**0.488**	−0.328	0.030	0.420

PC1, PCA factor 1; PC2, PCA factor 2; PC3, PCA factor 3; PC4, PCA factor 4.
Highest loadings on each factor are bold typed.

These dissimilarities between researches may be attributed to the diverse temperamental traits investigated using different experimental settings. Results of this study confirm that most of the differences between subjects seem to relate to individual behavioral differences and not to the sex.

Predictive validity

To assess predictive validity of the NOT, the relation with a validated questionnaire (Momozawa et al., 2005) was investigated. Most results concerning predictive validity are similar to those obtained by Górecka-Bruzda et al. (2011) in coldblooded horses. Table 3 lists the outcomes of the principal component analysis (PCA) performed on the scores of the questionnaire items. The analysis identified 4 main factors with Eigenvectors >1, which together explain 61.9% of the variation between horses. Figure 1 represents the PCA loadings on the first 2 factors. The first factor, accounting for 31.3% of the total variance, shows high negative loadings for "nervousness," "excitability," "panic," "inconsistent emotionality," and "skittishness" suggesting that horses registering high negative scores on this factor can be described as more aroused and fearful than horses with high positive scores. These questionnaire items were considered for further analysis as the authors assumed that they could potentially be related to other indicators of fearfulness as the latency to approach a novel object. The first factor is also characterized by positive loadings of questionnaire items relating to trainability ("concentration," "trainability," "cooperation," "perseverance," "trailer") and attitude toward humans ("docility," "friendliness toward people"). Fearfulness, attitude toward humans, and trainability might have common background in the sense that owners could have inappropriate reactions to fear displays affecting horses' propensity to cooperate with humans. The second factor accounts for 13.6% of the total variance and shows high positive loadings for "memory" and "vigilance," as opposed to "friendliness toward horses." This may suggest that horses with high positive loadings on this factor tend to be more alert. The meaning of the other 2 factors, accounting for 10.2% and 6.6% of the total variance, respectively, seems more elusive. The third factor shows high loadings for "curiosity" and "stubbornness" opposed to "timidity." Only "competitiveness" belongs to factor 4, so this factor retains the name

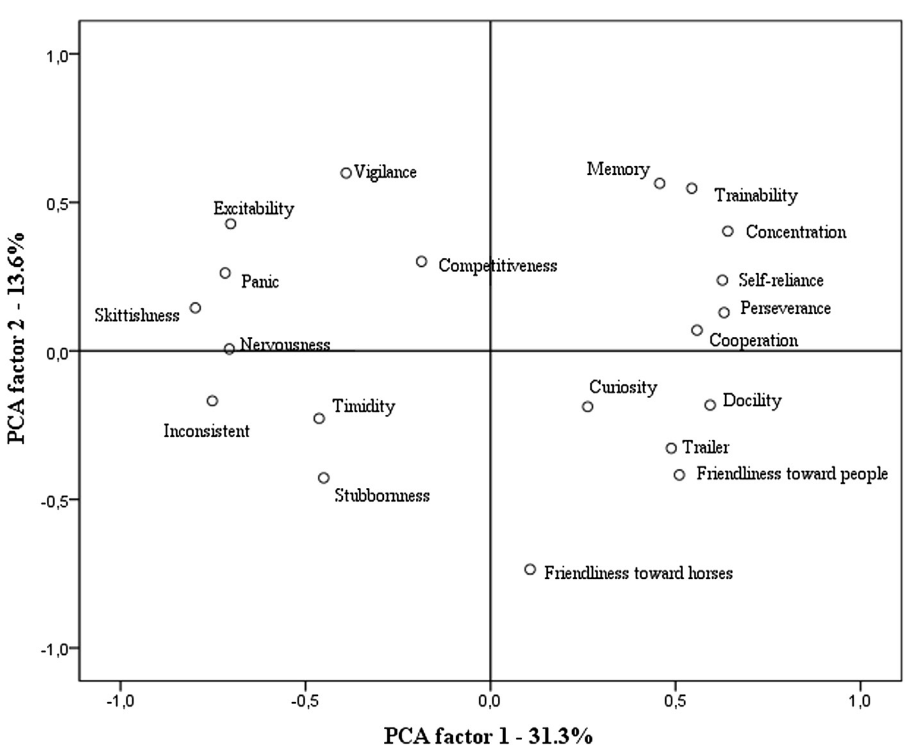

Figure 1. PCA loading plot of the questionnaire items on the first 2 factors.

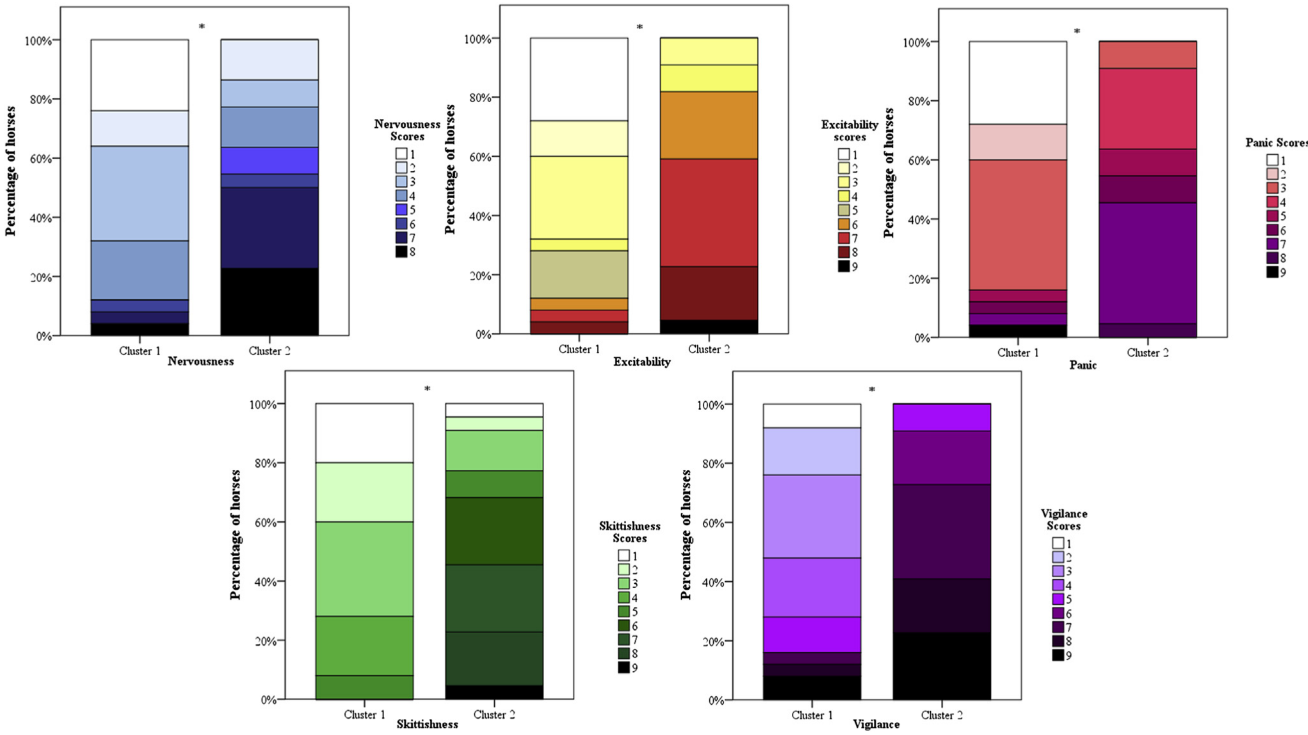

Figure 2. Proportion of horses with different questionnaire scores in the two clusters. *Mann-Whitney U test, $P < 0.001$. Cluster 1 = 26 horses, cluster 2 = 24 horses. (A color figure can be found in the online version of this article).

"competitiveness." The results of 2 questionnaire items, "stubbornness" and "friendliness toward horses," are difficult to explain unambiguously as they appear not to be meaningfully associated with the others. One possible explanation is that the owners interpreted these questions differently. Another explanation may be that the questionnaire was developed for a specific population (Japanese), and respondents with a different cultural background might interpret it differently. To avoid these drawbacks, the questionnaire has been discussed among authors, as described in Method section. Despite these precautions, our results indicate that some questions could have been interpreted in various ways; hence, correct wording of questionnaire items is essential.

A two-step cluster analysis was performed on questionnaire items relating to "arousal or anxiety" (negative loadings on the first factor) and latency to approach and reapproach the bottle in the fear test, to identify groups of horses that are similar to each other for the considered variables. Two clusters were found based on the 7 input variables selected. Fifty-two percent (N = 26) of the horses were assigned to the first cluster and 48% (N = 24) to the second. Horses in cluster 2 needed significantly more time to approach the bottle after it was dropped (Mann-Whitney U, $P < 0.01$) and were described by their caretakers as more prone to panic, vigilant, excitable, skittish, and nervous (Mann-Whitney U, $P < 0.001$; Figure 2). However, they did not differ in the latency time to approach the bottle when it was first placed at the box entrance (Mann-Whitney U, $P > 0.05$). The bottle, when used as a static novel object, probably did not possess features that induced a clear reaction of fear enabling the differentiation of horses with various levels of fearfulness. Other studies revealed a moderate correlation between behavior test outcomes and subjective evaluations of horse temperament provided by caretakers (Flentje, 2008; McCall et al., 2006; Visser et al., 2003b). For example, Momozawa et al. (2007, 2003) found comparable results in studies investigating correlations between the caretakers' responses about ordinary behaviors, heart rate, behavior, and latency times recorded during a balloon reaction test or an isolation stress test. Although questionnaire surveys have the advantage of being based on long-term observation, they have the flaw of being subject to bias based on respondents' personal beliefs and temperament. Moreover, they should be carried out solely among those who are familiar with the behavior of horses under different circumstances (Momozawa et al., 2007), as was the case in this study. When feasible and valid, standardized behavior tests represent a preferable asset to people who deal with horse temperament evaluation in a broad range of facilities as they prevent unreliability of participants' responses. Relationships between results of the NOT and evaluation of caretakers suggest that, to some extent, the NOT outcomes represent a fearfulness temperamental trait.

Convergent validity

Convergent validity of the NOT was evaluated by examining relations between the test outcomes and variation of lacrimal caruncle temperature. This study shows for the first time that lacrimal caruncle temperature of horses undergoing the NOT was significantly higher after the test compared to basal (mean temperature before the test: 35.90°C ± 0.59°C; mean temperature after the test: 36.19°C ± 0.60°C; Wilcoxon $P < 0.01$), indicating the presence of a physiological response to the test. Examples of thermographic pictures taken before and after the NOT are presented in Figure 3 (columns B and C, respectively). As shown in the figure, the temperature of the caruncle was higher in the post-test period (yellow and white areas), whereas it was relatively low before the NOT (orange areas). Furthermore, Nakayama et al. (2005) detected transient increases in temperature in the eye regions of 4 macachi rhesus (*Macaca mulatta*) during the stimulation of a potentially threatening person. Increased caruncle temperature was described by Stewart et al. (2007) in dairy cows injected with adrenocorticotropic hormone, corticotropin-releasing hormone, and epinephrine. However, the same authors reported contradictory findings in

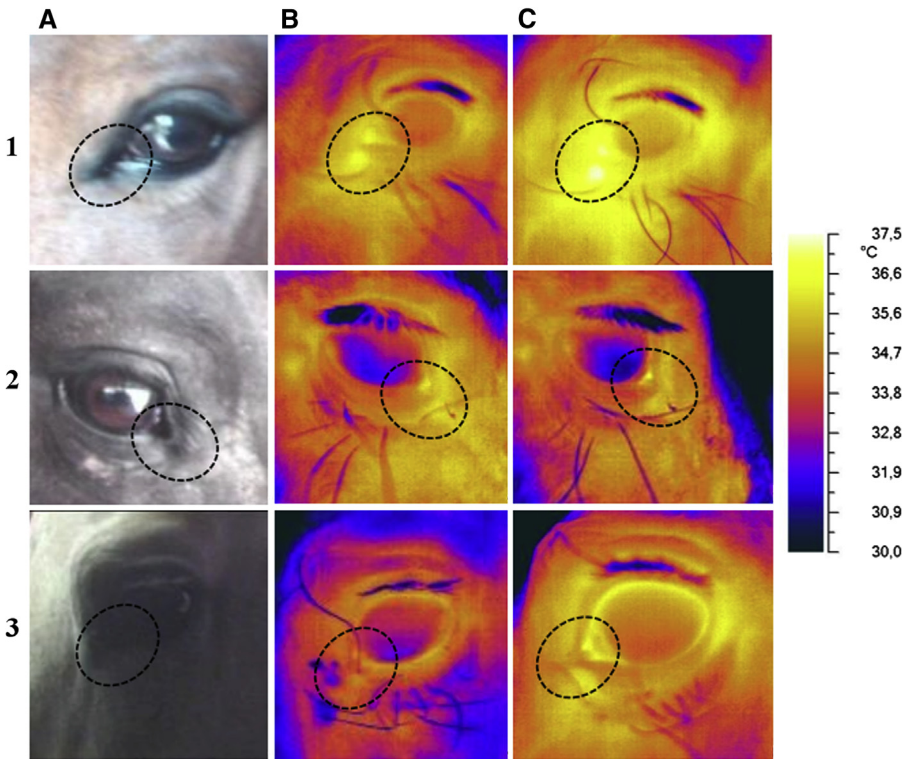

Figure 3. An example of changes in caruncle temperature of 3 horses. (A) Actual image. (B) Thermographic images before the novel object fear test (NOT). (C) Thermographic images after the NOT.

cattle undergoing fear-eliciting (being hit with a plastic tube on the rump, being startled by the sudden waving of a plastic bag, restraint, electric prod, startled accompanied by shouting; Stewart et al., 2008a) or painful stimuli (disbudding with or without local anesthetic; Stewart et al., 2008b). A possible reason for discrepancy between these studies may be because of the nature of the fear stimuli used as some of them might have caused pain besides fear. The magnitude of temperature variation was related to the intensity of reaction to the NOT; subjects that did not reapproach the bottle after it had been dropped in the box had a higher increase in lacrimal caruncle temperature (ANOVA $P < 0.1$; Figure 4). These results confirm that horses that experienced intense negative

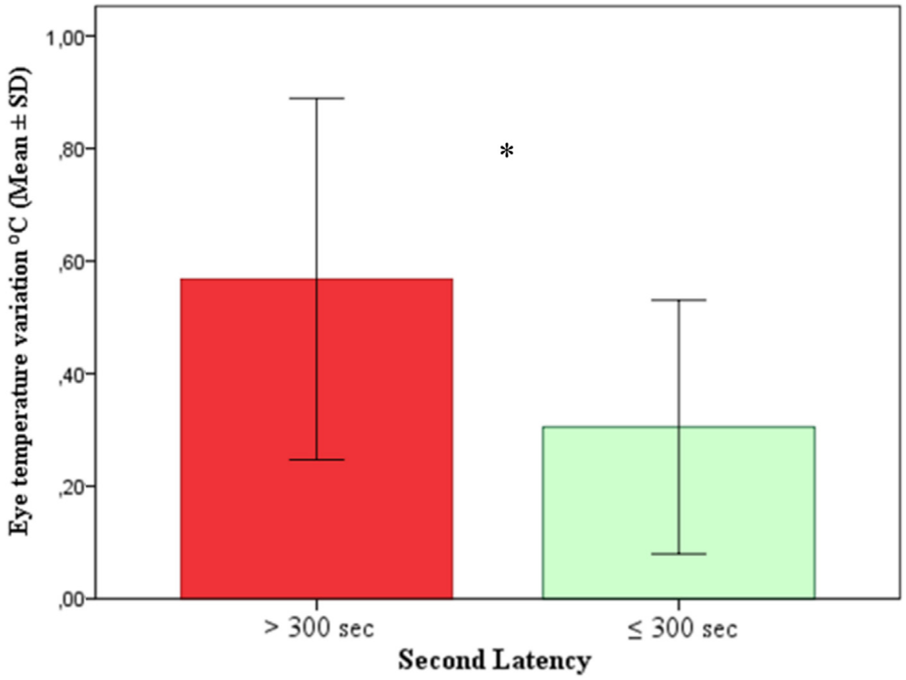

Figure 4. Caruncle temperature variation after fear test. *Analysis of variance $P < 0.1$.

Table 4
Descriptive results of human-animal relationship tests

Test	Score/time	Proportion/ mean ± SD
Avoidance distance	0 = the horse showed an avoidance reaction	22.9%
	1 = the horse accepted being touched	77.1%
Voluntary animal approach (latency), seconds		5.3 ± 6.7
Voluntary animal approach (behavior)	0 = the horse was aggressive	6.1%
	1 = the horse showed no interest in human presence	28.6%
	2 = the horse was interested and friendly	65.3%
Forced human approach	0 = the horse did not allow the touch	6.1%
	1 = the horse allowed the touch but then tried to move away	46.9%
	2 = the horse allowed the touch	47.0%

SD, standard deviation.

emotions during the fear test presented more evident behavioral signs related to fear (they do not reapproach the bottle) and higher variation in lacrimal caruncle temperature. Analogously to Vianna and Carrive (2005), who investigated changes in laboratory rats undergoing a conditioned fear response to footshock chambers and found that tail temperature was sensitive to the level of arousal, the findings of the present study suggest that the stronger the arousal, the stronger the physiological response.

Discriminant validity

Discriminant validity of the NOT was studied by examining the possible relationship with fear of people. Table 4 lists descriptive results of the 3 human-animal relationship tests. Fifty-six percent of the horses did not show any avoidance behavior when approached by the assessor in the avoidance distance test. In voluntary animal approach test and forced human approach tests, only 6.1% of the horses displayed negative reactions. The horses which had shown avoidance reactions during the avoidance distance test or negative reactions to the forced human approach test did not need more time to reapproach the novel object compared with horses that had expressed an amicable behavior toward humans during human-animal relationship tests (ANOVA Kruskal-Wallis, $P > 0.05$).

These results suggest that fear reactions shown in the NOT are not related to the responses of horses toward unfamiliar humans. Other research has failed to prove that different behavior tests effectively distinguish between fear of people and a more general fearfulness trait (Górecka-Bruzda et al., 2011). In this study, similarly to Visser et al. (2003a), we demonstrated that the NOT is specifically informative of the general fearfulness trait. These results do not support the hypothesis that reactivity to humans and general fearfulness belong to the same basic feature of temperament.

Conclusion and future directions

The fear test originally developed by Górecka-Bruzda et al. (2011), refined and adapted by the authors of this study to horses of different breeds and to different conditions, proved to be a valid measure of general fearfulness of horses and could be easily implemented for use in an on-farm welfare assessment protocol. The relatively limited number of subjects on which the thermographic measures were performed (N = 22) constitutes a limiting factor for the generalization of the results of the present study. In any case, our results are a valid indication for a relationship between superficial eye temperature and fear emotion. This study provides a new angle on mechanisms regulating interaction between horse emotions and behavior. Future studies should consider a larger sample of horses to substantiate the results and to measure time to return to baseline eye temperature after the fear stimulus.

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Ethical considerations

The work described in this article has been carried out in accordance with EU Directive 2010/63/EU for animal experiments. Horses were involved in this study at the request of their owner on a voluntary basis and approval by an ethical committee was not required.

Conflict of interest

The authors certify that there is not any actual or potential conflict of interest.

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RESEARCH

The roles of equine ethology and applied learning theory in horse-related human injuries

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Abstract Horse-related injuries to riders, handlers, and veterinarians can be both serious and long-term in their effects on the victim. This review of literature covering horse-related injuries to human beings sought to identify rider and handler injury incidence and the relationships between antecedents and demographics of incidents. Review and evaluation of previously recommended prevention strategies were also undertaken.

There was evidence that recent technological advances in protective equipment may have mitigated some injuries but the frequency of the incident has not changed. Despite several authors acknowledging the important role the horse played in many of the incidents, there was little specific detail about this role recorded. The emerging field of equitation science will contribute important insights that make horse-use safer by reducing the "unpredictability" aspect of horse–human interactions.

Introduction

Despite millennia of horse domestication and training, horse-riding and handling is still acknowledged as a dangerous pastime (Nelson and Bixby-Hammett, 1992; Abu-Zidan and Rao, 2003; Lim et al., 2003; Jagodzinski and DeMuri, 2005; Seibenga et al., 2006; Ball et al., 2007; Mayberry et al., 2007; Kiss et al., 2008; Bilaniuk et al., 2009). Although injuries incurred in horse-related incidents can be very serious and even fatal, recreational equestrian activities continue to grow in popularity in many parts of the world. Recent advances in learning theory and ethology as applied to horses in the form of equitation science are likely to reduce the injury risk to people involved with horses, for example, by clarifying ethological challenges at the horse–human interface (McGreevy et al., 2009). Demystifying horse-training should make horse interactions with human beings more predictable. Although the mechanisms that underpin effective training are being more broadly accepted, there is also opportunity for exploration of the communication processes between the 2 species (Feh and de Mazières, 1993; McGreevy et al., 2004; Keeling et al., 2009; McGreevy et al., 2009). To this end, we reviewed the data published in English over the past 20 years to collate the data available on injuries to human beings in horse-related incidents. We sought to identify any consistent trends in the demographics of those injured, causes of injury, risk factors for injury, role of personal protective equipment, and recommendations by authors of the articles for prevention of injury. We were particularly interested in identifying horse-related causes for human injuries.

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Materials and methods

A review of the articles cited was undertaken through the Web of Knowledge and Scopus databases using "horse-related injuries" and "equestrian injuries" as the search terms. We excluded articles that specifically covered the racing industry, as our aim was to target the sporting and leisure horse industry. We clustered data into the following 4 broad categories:

- Adult and child riders and non-riders (19 articles)
- Adult-only riders and non-riders (4 articles)
- Child-only riders and non-riders (3 articles)
- Veterinarians (2 articles)

Non-riders included horse handlers and bystanders. Veterinarians were included as a specific occupational group to compare whether handling injuries differed from handling injuries to owners. Because all articles reviewed used different measures for evaluating incident rates and injury severity, we tried to express as many of the variables as was possible as simple percentages. We also reviewed Australian Government statistics on horse-riding demographics using reports 4177.0 and 4901.0 downloaded from the Australian Bureau of Statistics website.

Results

Demographics of horse-riders

In its analysis of participation in sports, the Australian Bureau of Statistics (ABS, 2007) defines people aged >15 years as adults. It reports that the most populous cohort participating in horse-riding among persons aged >15 years was in the age group 35 to 44 years (27%), followed by the 25 to 34 years age group (20.6%). The 45 to 54 years age group made up 19.1% of horse-riding participants and the 18 to 24 year age group made up 16.4%. The 15 to 17 and the 55 to 64 years age groups made up 9.7% and 7.1% of the horse-riding participants, respectively. There were no data available from this resource on the age distribution of children involved in equestrian activities. Females made up 80% of adult (aged >15 years) participants in equestrian activities (ABS, 2007) and 86.8% of equestrian participants aged <15 years (ABS, 2009).

Demographics of those injured

Studies of adults and child riders only (Table 1) reported a bimodal pattern to injury frequency, with most injuries occurring in the second and fifth decades of life (Loder, 2008). Females predominated in younger age groups but males were more highly represented in older age groups. Some authors reported that although fewer males appeared in younger age groups, they often presented with more severe injuries as compared with their female counterparts (Jagodzinski and DeMuri, 2005; Cuenca et al., 2009). In the non-veterinary adults-only studies (Table 2), average age was reported to be within the fourth and fifth decades. Bilaniuk et al. (2009) found that patients older than 50 years were more likely to sustain fractures of ribs and thoracolumbar vertebrae, whereas patients younger than 50 years were more likely to present with concussion and fractures of the upper extremities. Upper extremity injuries also figured prominently in studies of equestrian-related trauma in children, with contusions, abrasions, and fractures showing a broadly equal frequency.

Patients aged <35 years were represented in greater numbers as compared with other age groups (Tables 2 and 3). Females represented 20% and 26%, respectively, of those injured in the veterinary studies (Table 4). No age-related data were recorded in these 2 studies.

Causes of injuries

The most common mechanism of injury in the studies, except for the veterinary-specific studies, was falling and/or being thrown from the horse (range, 46%-83% of incidents). Injuries among non-riders were most often caused by kicks (range, 0.8%-41% for riders and handlers, 7%-82% handler and bystanders). Veterinarians reported that 79% of injuries were caused by kicks (Lucas et al., 2009). Bites did not figure highly as a cause of injury.

Risk factors for injury

Jagodzinski and De Mura (2005) found significant risk factors for horse-related accidents included being female, participating in English-style riding, and riding 15 to 24 hours per month. Kiss et al. (2008) found that children who owned horses (or whose families owned horses) were more likely to receive injuries during handling.

Most of the studies found that riding incidents typically occurred within 3 years of the rider's first horse-riding experience. Clarke et al. (2008) showed that novice riders (categorized as those with fewer than 100 hours riding experience) were more vulnerable to accidents than riders with greater experience. In an earlier study, Ingemarson et al. (1989) had found that young horses and horses whose height was >148 cm were associated with an elevated risk of injury. They also observed lower risk in trotting than the galloping gaits.

Williams and Ashby (1995) reported that horse-related accidents were more common in warmer than in the cooler months. Accidents most often occurred in a field or paddock. This study also found horse behavior to be the most significant factor in horse-related incidents and that the majority of case reports alluded to the horse showing a fear response. Ball et al. (2007) also reported some factors related directly to the horses involved in their data set. In

Table 1 Summary of articles that covered children and adults

Author(s) and year of publication (Country period of data collection)	Accident rate per 100,000 people	Female (%)	Most frequent injury	Most frequent site of injury	Severity (ISS[a] score)	Hospitalization-related statistics	Age group features (years)	Most common mechanism of injury	Context	Rider-related features	Horse-related features
Abu-Zidan and Rao, 2003 (prospective hospital records, Australia, 1994-2000)		**59**	**Fractures**	**Head and face 27%, neck 5%, chest 8%, abdomen 6%, pelvis 8%, back 13%, upper limb 32%, lower limb 30%**	**Mean 7.2**	**100% as cases selected by hospital admission. Those that had more than one mechanism of injury stayed longer**	**Mean age females: 31 Mean age males: 38**	**Falls 67%, kicks 16%, other 17%**	**Park or public place 55% of incidents**	**Amateurs: 66%**	
Bilaniuk et al., 2009 (New Jersey, 2004-2007)		84		>50 yrs, rib fractures 23%, T-L-S spine fractures 18% <50 yrs, concussion 22%, upper extremity fracture 16%							
Chitnavis et al., 1996 (UK, 1991)		**75**		**Head 6%, upper limbs 42%, lower limb 38%**		**24%**	**10-20 yrs, 26%; 20-30 yrs 23%**	***Riders* (78% of caseload): Falls 83%, crushed by horse falling 14%, struck obstacles 55%, entrapment in reins 5% *Bystander/ handler* (22% of caseload): kicked or stamped on 82%, bitten 10%, run into by horse 8%**		**Amateurs: 75% professional: 25%**	
Cripps, 2000 (Australia Bureau of Statistics mortality records 1979-1998)	0.13 deaths per 100,000 people (7.8 horse-related deaths per 100,000 participants)	15-24 yrs of age: 54% 35-54 yrs of age: 29%					15-24 yrs (54% female) and 35-54 yrs (71% males)				

Cripps, 2000 (hospital data Australia Institute of Health and Welfare 1996-1997)	17 estimated incident cases of horse-related injury per 100,000 people	5-34 yrs of age: 58%. From age of 35 on, males have a higher accident rate than females	Fracture, intracranial injury	Upper extremity, head		Average length of stay 3 days	10-14 yrs,	Falls or being thrown			
Exadaktylos et al., 2002 (Bern, Switzerland, 2000-2001)		**65**	**Fractures or deep lacerations**	**Face[b]**			**Mean age, female: 27 Mean age, male: 31**	**21% of the 80 equestrian accidents seen at the hospital were from direct hoof kick. All unmounted; standing next to or behind horse.**			
(Japan, 1985-1991)			**Bruises (38.7%), fractures (23.2%), abrasions and lacerations (21.4%)**	**Lower limb 23.7%, shoulder and upper limb 20.4%, chest 17.7%**	**565 patients 0-9, 16 patients 10 or greater**			**Kicks 39.2%, falls 18.1%, trampling 15.3%**		**Handlers only**	
Ingemarson et al., 1989 (Sweden, 1969-1982)		More females than males injured until 25 years of age, then females and males same rate of injury until after 46 years of age when males have higher injury rate	Fracture of skull with cerebral contusion or laceration	Head 72%, chest 15%, abdomen 11%	NA	NA	Riding schools: 11-15 yrs Competition riders: 16-20 yrs	Falls 49%, kicks 16%, trampling 4%, horse rolling over 9%, miscellaneous 16%	68% falls in public places	59% had <6 yrs experience	Increased risk with younger horses, horses >148 cm, Less risk trotting

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Table 1 (*continued*)

Author(s) and year of publication (Country period of data collection)	Accident rate per 100,000 people	Female (%)	Most frequent injury	Most frequent site of injury	Severity (ISS[a] score)	Hospitalization-related statistics	Age group features (years)	Most common mechanism of injury	Context	Rider-related features	Horse-related features
Loder 2008 (retrospective NEISS system analysis USA 2002-2004)		66	Contusions/ abrasions 30.8%, fractures 28.3%, sprains/strains 17.6%, brain injuries 11.6%, lacerations 5.6%	Head and neck 28.9%, upper extremities 29.7%, lower extremities 16.4%, multiple body locations 1.1%			Average age 30.0 ± 17 yrs (33.8% <18 yrs)	Fall 58.7%, thrown or bucked from horse 22%, riding 8.6%, stepped or rolled on by horse 3.8%, kicked by horse 2.3%, performing ground care 1.9%, while mounting horse 1.8%, dragged by horse 0.4%, horse vs. motor vehicle 0.2%, shoeing horse 0.1%, miscella-neous 0.4%	At home 35.9%, recreation/ sporting facility 30.4%, on farm 18.5%, public property 12.3%, street or high-way 2.5%, school 0.5%		
Mayberry et al., 2007 (Retrospective survey of riders USA, 2003)		84	Bruises/ lacerations 46%, fractures 18%	Extremity 64%, chest 18%, face/ scalp 16%, brain 9%, neck 9%, spinal cord 3%, abdomen 3%, pelvis 2%			Median age, 44			*Riding skill level:* Novice 9.9%, intermediate 40.4%, advanced 36.5%, instructor or professional 12.4% High incidence of injury in first 18 hours of experi-ence then abrupt reduction by 80% at 100 hours. Near zero incidence at 5000 hours	
Moss et al., 2002 (United Kingdom, Surrey, 2000-2001)		**85**	**Fractures**	**Upper limb 29.2%, lower limb 22.3%, head 17.3%, multiple 11.2%, thoracolumbar 10.8%, pelvis 5%, neck 3.1%, abdomen 1.2%**			**Median age: 26**	**Falls 78.5%, kicks 11.1%, bites 0.8%, trodden on 5.4%, injury while leading horse 3.1%**			

Nelson and Bixby-Hammett, 1992 (Review of English language literature 1966-1991 mortality and hospital admission reviews)		Females predominate in mortality data (80% and 89%) and hospital admission data 68%-85%. Females suffer more injuries than males 52%-87%	Fractures 28%-48%	Upper extremities (30%-61%), head (10%-28%)			10-19 yrs	Falls[c]		
Newton and Nielsen, 2005 (Colorado, 2000-2003)		**38**	**Fractures**		**Average 8.5**	**Average hospital stay 72 hours**	**36-55 age range highest representation**	**Falls from horse 74%, stepped on by horse 9%, horse rolled on person 11%, head hit horse 2%, other 2%**	**70% incidents occurred during recreational pursuits, 68% were injured riding or tending rental horses**	**80% incidents due to loose cinches and saddle slip. *Rider carelessness, mismatching horse to rider*: Beginners: 55%, Novices: 10%, Experienced riders: 35%**
Smartt and Chalmers, 2009 (New Zealand, 2002-2003)	**233 per 100,000 but when include only "regular riders[d]", rate rises to 469 per 100,000. In 13-15 age group rises to 900 per 100,000**	66	**Fractures/dislocations of limb and girdle bones followed by skull, spine and pelvic bones**	**Head and neck 23%, abdomen or lower back 18%, lower leg 17%.**			**Median age, 31 but female cases younger (median 28 yrs vs. 38 yrs for males) 10-14 yrs age group highest number of incidents**	***Riders*: Falls 70% *Bystander/handlers*: Bitten/struck by horse 20%**	**41% during sport or leisure activities, 98.2% all cases were sustained during horse riding with <2% attributed to horse racing, polo and rodeo. Place of occurrence unspecified (32%), 24% on farm, only 1% were reported in a school**	
Sorli, 2000 (Review of health and coroner databases British Columbia, Canada, 1991-1996)		62	Fractures	Head 20%, upper limb 19%, lower limb, 18%, trunk 18%, spine 7%, unspecified makes up remainder[a]			25%: <10, 36%: 16-34, 37%: 35-83			

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Table 1 (*continued*)

Author(s) and year of publication (Country period of data collection)	Accident rate per 100,000 people	Female (%)	Most frequent injury	Most frequent site of injury	Severity (ISS[a] score)	Hospitalization-related statistics	Age group features (years)	Most common mechanism of injury	Context	Rider-related features	Horse-related features
Thomas et al., 2006 (Review of NEISS data USA 2001-2003)	**35.7 per 100,000 population p.a.**	**59**	**Contusions/abrasions 31.4%, fractures 25.2%, strains/sprains 15.8%, concussion/internal head injury 9.7%, lacerations 7.7%, haematoma1.8%, dislocations 1.8%, other/unknown 6.6%**	**Head/neck 22.3%, upper trunk 17.7%, lower trunk 14.6%, upper extremities 21.5%, lower extremities 22.2%, other 0.9%**			**12% 10-14, 9.8% 15-19, 10.3% 35-39, 11.5% 40-44**	**Fall 78.9%, struck by or against 24%, crush 13.2%, overexertion 5.3%, bite 1.7%, other 0.7%**			
Williams and Ashby, 1995 (Victoria, Australia, collection periods varied by hospital but were in the period 1988-1995)	**16 (whole state = 18)**	**Of cases involving children: 77 Of cases involving adults: 59**	**Fractures followed by soft-tissue injury. Fractures accounted for 43% of child injuries and 30% of adult injuries; soft-tissue injuries 335 child injuries and 29% adult injuries**	**Upper limbs (50% children, 34% adults), lower limbs (17% children, 27% adults), head and face (22% children, 20% adults), rib fractures (4% of adults only), face and scalp 4%**		**27% (but 48% in total required referral or review after initial consultation in ER)**	**10-19yrs**	**Falls (77% of all cases), crushes—horse rolled on or stood on victim (7%), kicks (4%), rider being dragged (2%)**	**Accidents more common in warmer months, field/paddock most common site of incident. Horse behavior largest factor in accident (39%)**	**97% of cases occurred when riding the horse**	**Horse behavior given as factor in 61% accidents involving children (compared with 39% of those involving adults)**
As above, retrospective study 1991-1993		56		Extremities, then head or spine, then trunk		24%				Professional: 76% Recreational: 24%	

Bold entries include data on handler injuries.

[a]Injury Severity Score.

[b]All patients reported wearing a helmet at the time of injury but, as noted by the authors, helmets do not protect the face.

[c]Unable to determine if some of these injuries occurred during handling rather than riding.

[d]"Regular riders" being defined in this study as children over 5 years and adults who had ridden at any time in the last month.

their study, horses had a median age of 7 years and between 0 to 60 months of training. Both Ball et al. (2007) and Newton and Nielsen (2005) retrospectively interviewed patients about the accidents and therefore provided information on the cause of those accidents. The causes they listed included horse having "spooked," horse not having been trained for riders' "input demands," bad temperament (presumably of the horse), equipment failure (including loose girths/cinches), rider inexperience or carelessness, and the rider "simply having fallen."

In a study by Ball et al. (2007), riders had a mean of 27 years experience. In contrast, Ng and Chung (2004) and Abu-Zidan and Rao (2003) found no association between rate of hospital admission and a rider's status (leisure or professional), previous riding or injury experiences, or presence of supervision at the time of riding. Similarly, Kriss and Kriss's report (1997) also showed no correlation between victims' age, gender, or level of experience.

Common injuries

The areas of the body most vulnerable to horse-related injury are the head, hand or wrist, foot or ankle, and spinal cord or vertebral column. There is some evidence that older riders may be more vulnerable to thoracic injury. Contusions, abrasions, and fractures figure prominently. Concussion and brain injury were reported commonly in studies in which helmet usage was limited.

Effect of personal protective equipment

More recent articles found that improvements in helmet design and greater acceptance of the need to wear helmets when riding have helped to reduce the number of head traumas arising from horse-related accidents (Chitnavis et al., 1996; Moss et al., 2002; Abu-Zidan and Rao, 2003; Lim et al., 2003; Mayberry et al., 2007). There was some evidence that helmeted riders may sustain more facial injuries (Lim et al., 2003). Several articles predicted that the advent and adoption of protective vests may contribute to a drop in trunk injuries (Ball et al., 2007; Kiss et al., 2008; Bilaniuk et al., 2009), but the effectiveness of these vests has not been fully evaluated (Thomas et al., 2006). Protective footwear that provides ankle support has also been advocated to prevent ankle and foot injuries associated with horse-related incidents (Ceroni et al., 2007).

Injury-prevention strategies

A summary of prevention strategies proposed by the authors of articles within the current review appears in Table 5. Lucas et al. (2009) also suggested that personal protective equipment, such as helmets and vests, may prevent serious injury to veterinarians treating horses.

Discussion

Generally, the studies considered in the current review agree that horse-riding and handling are dangerous activities. Factors contributing to the inherent dangers of contact with horses include the size and unpredictable nature of horses, elevation of riders on horseback well above the ground, the kicking force of the horse, which is estimated to be approximately 1,000 N, and the speed of horses (up to 65 km/hr).

There was agreement that horse-related incidents can lead to a wide range of injuries, from mild contusions to death. Kiss et al. (2008) noted that one quarter of all lethal sport injuries in children are caused by horse-riding, whereas Ceroni (2007) concurred with the previous research, reporting that horse-riders can expect to be involved in a serious accident once in every 350 hours of contact time. In contrast, motor-cyclists have an expected rate of 1 serious accident every 7,000 hours. Furthermore, horse-riding injuries were responsible for significant numbers of hospital admittance days across the studies. Ten of the articles listed hospital admissions, with 5 specifying average hospital stays of 3 days or more (Cripps, 2000; Newton and Nielsen, 2005; Ball et al., 2007; Kiss et al., 2008; Cuenca et al., 2009).

Several studies reported a horse-related accident rate ranging from 16 to 233 per 100,000 people (Williams and Ashby, 1995; Jagodzinski and DeMuri, 2005; Smartt and Chalmers, 2009). When only "regular riders" were included, the rate rose to 469 per 100,000 (Smartt and Chalmers, 2009). This compares with a dog-related injury rates of 12.1 per 100,000 for males and 10.4 per 100,000 for females (Renate and James, 2005). Despite the higher injury rate associated with horses, there is a glaring omission of legislation covering horse-related activities in many countries (Fleming et al., 2001; Thomas et al., 2006), even though legislation designed to mitigate injury exists for apparently less common motor-cycle or dog-related incidents.

Demographics of those injured

The age- and gender-related distribution of horse-related accidents may simply reflect the demographics of the riding population. Figures from the Australian Bureau of Statistics show that the highest percentage of adults riding horses coincides with the highest frequency of adult injuries in the fourth and fifth decades of life. The ratio of females to males (6:1) aged <15 years participating in horse-riding activities, as reported in 4901.0 Children's Participation in Cultural and Leisure Activities (ABS, 2009) corresponds broadly to the ratio of injuries to females and males found in several of the articles covering this age group (Table 3).

Novice riders in their first 100 hours of riding appear to be at more risk of horse-related injury (Mayberry et al., 2007) and this would account for the high number of females in the 10 to 14 years age group represented in many of the studies, as presumably many children are beginning their riding careers in this period. It does not account for handling and riding injuries being more common among horse-owning human beings, or explain why males, especially those in their fourth or fifth decade, should be more likely to suffer serious injury than females in the same age group. Cuenca et al. (2009) noted that younger males in their study were less likely to wear helmets or other safety gear. Perhaps, older males take more risks or ride the more unpredictable animals. Williams and Ashby (1995) also suggest that higher representation of males in the 40- to 49-year age group is a reflection of occupational injury. Several studies found that experience did not necessarily moderate the severity of injuries and that risk of serious injury, including those among veterinarians, could be a function of cumulative exposure (Ball et al., 2007; Loder, 2008; Lucas et al., 2009). Arguably, experience in itself would not be preventative if new knowledge has not been incorporated into practice. Alternatively, it would be useful to identify if more experienced horse-riders and handlers are exposed to more reactive horses as part of their cumulative exposure.

If serious injury is a likely result of exposure to horses, then the centuries of horse management, training, and education to date appear to have done little to prevent injuries to human beings in their interactions with equids.

McGreevy et al. (2009) argue that because riding horses has no biological analogues in nature, riders and trainers must use learning theory and novel interspecific signals to control the horse under saddle. This underpins the importance of consistent and well-timed signals to elicit clear locomotory responses in the horse and the need to minimize horses' autonomy when they are ridden or handled. Failure to do so will result in ethologically predictable, but potentially very dangerous, flight or fight responses to permeate the ridden (and handled) horse's behavior. Confusion among horses can often result when novice riders, who have yet to develop adequate skills, body control, or balance, apply pressure signals that are inconsistent and independent of attempts to stay on-board. Furthermore, to be safe when ridden, horses must be under the control of interspecies signaling system rather than environmental stimuli. The good news is that there appears to be only a small number of signals from human beings that are required to cue even the most elaborate equine responses (e.g., in elite level equestrian sport).

Causes of injuries

There are many reasons that a rider may fall from a horse. Sometimes the rider simply loses balance. The growing understanding of the influence of the rider on the horse's stability and balance (Peham et al., 2004; Lagarde et al., 2005; Peham et al., 2008; Symes and Ellis, 2009) has yet to be acknowledged in published data on horse-related injury. There is no current reliable measure of what constitutes a secure seat or how this can be evaluated. Being physically capable of controlling reins does not necessarily confer immediate control of the horse if the horse has not been trained to respond to the negative reinforcement mechanisms that rein pressure is intended to elicit. Changes in the horse's gait and direction unforeseen by the rider can also unseat the rider.

Poor stimulus control of the horse by the rider and activation of the flight response are two aspects of horse–rider interactions that warrant further investigation as a means of preventing or mitigating horse-related accidents (McGreevy and McLean, 2007). Records of the type of apparatus being used at the time of any injury may assist in analyzing the controllable aspects of the horse–rider interaction. Avoidance of severe bits may at first glance seem to reduce the rider's control. However, it may also speak of the need for stronger bits as a result of habituation to milder ones. A more thorough understanding of bit mechanism and its role in negative reinforcement reveals how habituation to bit pressure actually makes the horse's response more unpredictable. Any move toward milder biting apparatus must be accompanied by an improved understanding of learning theory (Warren-Smith and McGreevy, 2008). In the long-term, the use of modern materials, such as "smart textiles" that are self-tightening (for cinches) or "memory foam," may lead to the development of safer equipment than is currently available.

The finding that the "galloping gaits" are associated with more accidents is not surprising; not only do they involve higher velocity, but the biomechanics of these gaits dictate that the rider experiences forces in the medial/lateral as well as in the cranial/caudal plane (Johnston et al., 2004; Lagarde et al., 2005; Lovett et al., 2005).

Handlers, including veterinarians, and bystanders are most commonly injured by horse kicks. Kicking is a normal part of the equid ethogram (McDonnell and Haviland, 1995) and one of the few active defense mechanisms that the horse possesses to deter aversive stimuli. In very young foals, the kick is a reflex response to pressure on the plantar aspect of the hind limb (Waring, 2003). A kick is, therefore, potentially the usual response to a stimulus that is unidentified or alarming. Horses may have to actively learn to suppress this natural behavior through habituation or operant conditioning when a human being is in close proximity to their hind limbs. The behavior of the human being sometimes overrides this habituation (e.g., when administering a needle or appearing suddenly behind a horse) so that the horse becomes more likely to kick.

Effect of personal protective equipment

Personal protective equipment has reduced the severity of some horse-related injuries among riders. Equipment, such as helmets (particularly those with face guards) and protective vests, could also reduce injuries to horse handlers

Table 2 Summary of articles covering adults only

Author(s) and year of publication (Country period of data collection)	Female (%)	Death rate	Most frequent injury	Most frequent site of injury	Severity (ISS[a] score)	Hospitalization	Mean age group (years)	Most common mechanism of injury	Context	Rider-related features	Horse-related features
Ball et al., 2007 (Canada 1995-2005)	40	7%	Fractures, pneumothoraces and hemothoraces	Chest 54%, head 48%, abdomen 22%, skull 18%, extremity fractures 17%, spinal fractures 17%, pelvic fractures 15%, spinal cord 6%, neck 1%	Mean 20 (required a ISS >12 to be admitted to study)	13 days	47	60% falling from horse, 16% crushed by falling horse, 8% kicked, 4% stepped on, 13% other[b]	Outdoors 88%, wide open spaces 45%, dry dirt 38%, uncultivated land 37%, sunny 87%, summer 55%, afternoons 53%	Mean 27 yrs experience, rode Western style. 6% riders <1 yr experience, 47% riders had been injured previously	Horse median age 7 yrs and training range 0-60 months. Horse "spooked" 35%, not trained for rider's input demands 27%, bad temperament 15%, simply fell 12%, equipment failure 6%, rider inexperience 5%
Johns et al., 2004 (retrospective study hospital admissions Auckland, New Zealand, 1994-2001)	76	Only fatalities studied		Soft tissue 29% Upper extremities 25%, lower extremities 24%, head 19%	Mean 5		34	29% falling from horse, 17% thrown from horse, 23% crushed by horse, 18% kicked[b]		Leisure riders predominate	
Ng and Chung, 2004 (prospective study Hong Kong, 2002)			**Minor injuries 60%, fractures and dislocations 29.1%**	**Upper limb injuries 23.6%**			**33**	**Riders: falling from horse 60%, non-riding 72%, kicked or trodden on 7%**		**No association between rider's status, previous riding or injury experiences or presence of supervision at time of riding with rate of admission**	
Clarke et al., 2008 (Ohio, 1993-2004)	**50**	**7%**	**Orthopedics 19%, neurosurgery 6%, general surgery 5%, urology/ vascular 8%**	**Head and face 38%, thoracic 26%, spinal column or cord 22%, pelvis 21%, extremity injuries 21%**	**35 ± 8 in non survivors**	**15.5 surgery patients, 12.3 non-surgery patients**	**42**	**Fall from horse 68%, crush 12%, kicked 8%, trampled on 5% (interpreted from graph)**		**Novice riders (i.e., <100 hours riding) more vulnerable to accident**	

Bold entries include data on handler injuries.
[a]There was trend for kick injuries to occur at work rather than in the leisure-riding environment.
[b]Unable to determine if some of these injuries occurred during handling rather than riding.

Table 3 Summary of articles covering children only

Author(s) and year of publication (Country period of data collection)	Female (%)	Most frequent injury	Most frequent site of injury	Hospitalization	Age-related data (years)	Most common mechanism of injury	Context	Rider-related features	Horse-related features
Jagodzinski and DeMuri, 2005 (USA 2002)	**62 except more males in <4 yrs age group**	**Contusions/ abrasions 28.6%, fractures 27.7%**	**Head and face 38%, upper extremities 24%, lower extremities 20%, chest 9%, abdomen 8%, pelvis 4%, neck/cervical spine 4%, back/thoracolumbar spine 8%**			***Mounted*: Falls from horse 52%, fell off and kicked 4%, fell off and stepped on 4%, fell off and dragged, entrapped or other 5% *Unmounted*: kicked 29%, stepped on by horse 4%, crushed or dragged by horse 2%**	**Sporting venues most common, followed by home**	***Risk factors*: Female OR (odds ratio) = 1.81, English-style riding OR = 1.77, riding 15-24 hours per month OR = 2.04**	
Kiss et al., 2008 (Hungary, Austria 1999-2003)	**90**	**Contusions**	***Riding*: Head/neck 24%, upper arm 14%, forearm 6%, wrist/ hand17%, trunk 22%, lower leg 4%, ankle foot 12%, *Handling*: Head/neck 19%, upper arm 45%, forearm 15%, wrist/ hand 19%, trunk 24%, lower leg 4%, ankle foot 15%**	**Children with familiar horse average hospital stay 2.88 days Children with unfamiliar horse average hospital stay 7.33 days**	**Mean age: 11**	**Falling from horseback 70.5%, falls with horse 6.3%, kicks 0.8%, bites 4.5%, collision 2.7%, trampling 2.7%, other 3.6%**		**Incidents typically occur 3 yrs after first horse-riding experience**	**Ownership of horse associated with more injuries during handling but injuries associated with riding more common if children did not own horse**
Cuenca et al., 2009 (Florida, 11-yr period)	82, although boys more likely to have polytrauma	Lacerations and contusions 58%, orthopedic 31%	Orthopedic 34%, Head 23%, Abdominal 21%, Chest 11%, Multiple 13%	50% required admission (64% without helmets vs. 39%, with helmets). Average stay 4 days	Median age: 12			82% falling or thrown, 6% kicked, trampled or trapped under animal[a]	12% during competition

Bold entries include data on handler injuries.
[a]Unable to determine whether some of these injuries occurred during handling rather than riding.

Table 4 Injuries to equine veterinarians

Author(s) and year of publication (Country period of data collection)	Female (%)	Most common place of injury	Most common activity at time of injury	Most frequent nature of injury	Most frequent site of injury	Treatment received	Mean period lost from work (days)	Use of safety precautions	Most common mechanism of injury
Landercasper et al., 1988 (Retrospective survey, Minnesota, Wisconsin.)	20			Lacerations	Hand		8.5		Kick
Lucas et al., 2009 (Retrospective survey, Australia. 1960-2000)	26	37.7% in stock or handling yards, 36.6% open paddock, 15.7% stables	Surgical (wound care, gelding) and medical procedures (nasogastric tubing)	Dislocations and fractures of face and/or thorax	Lower extremities 33%, head and neck 26%	18.8% hospital admission, 17.4% emergency room treatment only	7.4	34% used restraint of horse	Kicked or struck by horse (79%)

and bystanders. However, it should be noted that even current "gold-standard" helmets are not designed to withstand the focused force within a direct blow from a horse kick. Despite the undeniable evidence that wearing personal protective equipment does reduce the severity of horse-related injury, some authors noted a resistance to do so among certain riders (Ball et al., 2007). It is unclear whether this resistance is cultural or based on factors such as personal comfort. Extremity injuries may be reduced through the use of protective equipment, such as pads and gloves, similar to those designed for motorcycle racing. That said, personal protective equipment is effective only in mitigating the damage that can be incurred. Of course, it does not prevent the dangerous situation arising in the first place.

Preventative strategies

The "unpredictable" nature of horses is commonly cited as a cause of human injury. Recent advances in ethology and equitation science may make horse behavior more predictable (McLean and McGreevy, 2010). A clear understanding of the probable behavior patterns a horse can exhibit in a given context would help riders and handlers to predict and manage such behaviors. Horse trainers may be able to address this aspect of horse behavior through a more thorough application of current advances in learning theory (McLean, 2008; McLean and McLean, 2008).

We question the practicality of some of the preventative suggestions listed in Table 5. The concept of close supervision is laudable but, in practice, a horse that is shying, bucking, rearing, or bolting, (i.e., displaying flight responses) will not respond safely to indirect instruction or intervention by even the most experienced supervisor. The only supervisors who could be effective in these circumstances would have some control of the horse through a long rein or lead and would need considerable knowledge and skill. Similarly, indoor facilities are not always available and it seems impractical to ask riders to stay indoors and avoid "unsuitable" terrain until they have accrued 3 years of experience. Finally, it is obviously impossible to "avoid hind legs of horses at all times."

As horse behavior figures so prominently as a precipitating factor in as many as 61% of incidents (Williams and Ashby, 1995), consideration of variables associated with the horses must form the foundation of effective injury prevention and mitigation. We agree with Nelson and Bixby-Hammett (1992) that further research for data on safety around the breed and training of the horse are needed. Application of recently developed knowledge on breed-typical behavior (Lloyd et al., 2008) could help horse-riders and trainers make informed choices on the suitability of certain breeds for work requirements. Breeds that score lower on anxiousness and excitability presumably make better mounts for novice (and therefore unpredictable) riders. Ingemarson et al. (1989) observed that young horses are

Table 5 Accident-prevention strategies identified by authors in articles on horse-related injuries in humans

Horse-related factors	Rider-/handler-related factors	Parental/instructor factors	Equipment factors	Environmental factors
Horse fed and watered	Children to be developmentally capable of a secure seat and to control extremities in order to control horse through reins	Close parental supervision of children	Regular thorough checking of tack. Saddle fit should be snug and stirrup size appropriate for rider	Avoid excessively soft or muddy ground and ditches, holes, and uneven terrain with rocks or exercise caution if these surfaces are unavoidable
Smaller horses, temperament of horse	Training in horse safety (e.g., horse behavior, falling techniques, banning wrapping reins or leads around limbs or neck)	Good knowledge of horses and their behavior	Safety stirrups should be used	Riders to be limited to indoor schools until greater than 3 yrs' experience
Avoid hindlegs of horses at all times	Rider's skill level matched to appropriate horse (e.g., novice riders on horses older than 5 yrs)	Parental training schemes in horse behavior and risks involved	Avoid bareback riding	
	Children to be warned of horse "danger zones"		Personal protective equipment to be used when riding and handling horses (e.g., mouth-guards, face-shields, non-stick protective gloves), appropriate footwear (e.g., support the ankle, smooth soles, definite heel), safety vests/chest protectors, approved helmets, adoption of wrist protectors	
	Senior riders should take steps to prevent osteoporosis			
	Avoid alcohol consumption before and during horse activities			

more commonly associated with accidents, implying that older horses behave differently. In learning theory terms, it would be appropriate to conclude that older horses are more habituated to their environment or in optimal practice have well-consolidated and reliable responses and are therefore less reactive. This would be perceived as their behavior being more predictable. Alternatively, horses that have behaved too unpredictably (as perceived by their human handlers) may have been culled from the riding population over time. This possibility is reflected in Ödberg and Bouissou's (1999) study showing that wastage in young horses is often because of perceived behavioral problems. We can only speculate that taller horses are associated more with serious injury (Ingemarson et al., 1989) because there is farther to fall.

Recent advances in applying learning theory to horses contradict Mayberry et al.'s (2007) view that horses cannot be fully tamed. Horses with poorly trained acceleration and deceleration responses, both in-hand and under-saddle, show a positive correlation with unpredictable hyper-reactive and conflict behaviors (especially elements of the flight response). Retraining of basic operant responses must form part of everyday horse–human interactions to reinforce obedient and predictable equine behavior (McLean, 2005). An understanding by riders, instructors, and parents of the role of learning theory and desensitization in horse-training (Christensen et al., 2006; McLean, 2008) would also reduce conflict and confusion in the horse and rider/handler dyad. The same can be said for practical application of knowledge about the action and effect of equipment on horses (Quick and Warren-Smith, 2009; Meschan et al., 2007). Keeling et al.'s (2009) recent study showed that horses appear to be affected by the arousal state of their riders or handlers. The rider also influences a horse's gaits (Peham et al., 2004) and may play an underestimated role in disturbing the horse's centre of balance causing the horse to stumble or become less predictable in its gaits. Many of the preventative strategies suggested by the articles reviewed here call for more training in horse behavior for horse-riders and handlers. This should include evidence-based explanations of learning theory and equine ethology (McGreevy et al., 2009). Just as horses and riders cannot be considered as separate entities when assessing performance, strategies for preventing injuries must always include the equine member of the dyad.

Conclusions

Horse-related injuries to human beings are relatively common, and unfortunately, can have a profound effect on the quality of life of the injured human being. Numerous studies over the past 2 decades have reported factors as recorded by medical staff that may have contributed to incidents involving horses. However, generally collation of horse-related factors is only limited in these studies and verification of the horse's behavior and the specific stimuli to which it was responding in the context of the incident is virtually absent. We propose that, in light of the increasing body of knowledge related to horse behavior, emphasis should be placed on the epidemiology of horse behavior in horse-related accidents so that more effective preventative strategies can be implemented. Such strategies should include incorporating learning theory principles into horse and rider training to reduce flight and defense responses in horses (particularly in those destined for novice and child riders and handlers), and the generation of effective, verified, safety protocols when riding and handling horses. Legislation requiring the mandatory wearing of approved helmets and footwear should be encouraged. As equitation science gains currency as a way to study and improve horse welfare and performance, it is important to acknowledge the roles of equine ethology and learning theory in enhancing rider safety.

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Horse-riding accidents: When the human-animal relationship goes wrong!

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Accident surveys have indicated that horse riding is among the top 10 most dangerous sports and second only to motor racing if the severity of the accident is considered. While the recommendation to wear a safety hat may reduce the severity, it can not prevent accidents. To obtain a better understanding of the relative contributions of horse and rider, patients going to a hospital because of a horse related accident were asked to fill out a questionnaire about themselves, the horse, the management and training of the horse, and the circumstances around the accident. The aim of the study was to investigate the most common reasons for horse accidents and to identify possible ways to prevent similar accidents in the future.

Over a period of 3 years, 385 patients were questioned (response rate = 76%). The distribution of horse breeds was not significantly different from expected, although there were approximately twice as many accidents with large ponies (13%) compared to small ponies (6.2%). Probably linked to this result, we found that the 13-25 year age group of riders was over represented in our study (50%) compared to the expected (29%) from the distribution of Swedish Equestrian Federation members. When riders were asked to assess their own level of experience 65% assessed themselves as above average (4 or 5 on the 5-point scale) whereas only 13% considered themselves below average (1 or 2 on the scale). It may be that the people in our study were more experienced, riding under more dangerous conditions, but this finding can be compared with studies of car drivers where it has been shown that people in high risk groups have a tendency to think they are better drivers than others and over estimate their own capability. The results of our study may reflect that teenagers believe that they are better horse riders than they really are.

Accidents were divided into four categories. Pure accidents (33%) which would be difficult for the rider to foresee. The horse being frightened (27%) which probably reflects the horse’s natural instinct to flee from danger. Misunderstandings between horse and rider (22%) of which 43% happened during show jumping. Disobedience was the fourth category of accident (18%). Several factors tended to influence the type of accident, but one important contributing factor was how much of the routine care and management the person did themselves. People involved in pure accidents and accidents caused by the horse being frightened did more of the management (median = 4 out of a maximum of 5) compared to people involved in accidents caused by misunderstandings between the horse and rider or the horse being disobedient (median = 2).

Although the survey is unable to demonstrate direct connections between housing or management procedures and accidents, it supports the notion that the experience of the rider and his or her familiarity with the horse constitute important safety aspects in horse riding.

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Temperament in Preweanling Horses: Development of Reactions to Humans and Novelty, and Startle Responses

ABSTRACT: *The purpose of this study was to investigate the development and the stability across situations and over time of three temperament traits in young foals: propensity to react to humans, propensity to react to novelty, and propensity to react to suddenness. In a comparative study, we examined the reactions of animals in three independent groups (N = 27) tested at 3, 12, and 24 weeks of age, respectively. We observed that human avoidance and novel object approach behaviors are quasi inexistent in the group tested at 3 weeks, but are more and more present in the groups tested at subsequent ages. In a longitudinal study, we tested 48 foals successively at 3, 6, 12, and 24 weeks of age. Since reactions appear progressively with time, no stability over time or across situations was found. However, once a foal manifests a behavioral reaction at a given age, it will always reproduce this reaction subsequently. © 2007 Wiley Periodicals, Inc.* Dev Psychobiol 49: 501–513, 2007.

Keywords: *Equus caballus; horses; foals; temperament; ontogeny; fearfulness; novelty; startle response; reactions to humans; approach/avoidance reactions*

INTRODUCTION

Temperament is generally defined as a set of individual differences in behavioral tendencies that are present early in life and are relatively stable across various kinds of situations and over the course of time (Bates, 1987; Goldsmith et al., 1987). These behavioral tendencies are called dimensions or traits (Eysenck, 1967), and include fearfulness, activity, sociability, aggressiveness, etc. (for a review, see Gosling, 2001).

The stability across situations of the behavioral expression of dimensions or traits such as fearfulness, or type of reaction toward humans (e.g., approach or avoidance) has been studied in numerous species. For example, many correlations have been found between reactions to different fear-inducing situations such as tonic immobility tests, fear-conditioning tests or tests involving novelty or suddenness (Boissy, 1998 for review). Consistency has also been found between different reactions to humans, such as reactions to a passive or active human (e.g., sheep: Vandenheede, Bouissou, & Picard, 1998; calves: de Passillé, Rushen, & Martin., 1995; horses: Lansade, Bouissou, & Le Pape, 2003; Viérin, Bouissou, Vandenheede, Trillaud-Geyl, & Arnaud, 1998). Consistency between fearfulness and reactivity to humans is debatable: it has been observed in some studies (sheep: Romeyer & Bouissou, 1992; calves: de Passillé et al., 1995; horses: Viérin et al., 1998), and not in others (cattle: Boivin, Le Neindre, Chupin, Garel, & Trillat, 1992; poultry: Jones, & Waddington, 1992).

Concerning stability over time, consistent fear reactions over a period of a few months have been found in poultry (Webster & Hurnik, 1990), pigs (Kooij et al., 2002), calves (Jensen, Munksgaard, Mogensen, & Krohn,

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1999; Van Reenen et al., 2004), and dogs (Goddard & Beilharz, 1984). In postweaned horses, fear reactions measured during tests involving novelty or suddenness are constant both in the short term (during 1 month: Visser et al., 2001) and long term (from 8 months to 2.5 years of age: Lansade et al., 2003). Continuity of type of reaction toward humans over several months has also been reported in pigs (Kooij et al.), sheep (Kilgour, 1998), bighorn ewes (Réale, Gallant, Leblanc, & Festa-Bianchet, 2000), goats (Lyons, Price, & Moberg, 1988), and heifers (Kerr & Wood-Gush, 1987). In horses, behavior recorded during a handling test remained constant from 8 months to 2.5 years of age (Lansade et al., 2003; Visser et al., 2001).

The behavioral manifestation of temperamental traits is the result of a process of ontogeny. Therefore, in young animals, this manifestation can change according to maturation and environmental experience (Thomas & Chess, 1977; Zuckerman, 1991). For example, fear reactions are not usually present in very young individuals but generally emerge progressively over time. Children under two show no sign of fear of snakes; between three and four they show signs of cautiousness, and at 4 years and above they show definite signs of fear which increase with age. A similar phenomenon has been found in chimpanzees. Likewise, fear reactions to darkness, animals, strangers or heights develop in human infants between 8 months and 4 years of age (Gray, 1987).

The gradual emergence of behavior patterns during development has also been studied in species other than primates. In the domestic chick, fear responses, especially avoidance reactions toward a novel object (Andrew & Brennan, 1983; Bateson, 1964; Salzen, 1979) and avoidance of humans (Jones, 1995), increase in intensity from very low levels at 1 day of age to high levels at 9 or 10 days of age. In altricial mammals such as rats, the freezing reaction (from which fearfulness can be inferred) appears progressively within the first 20 days of life (Hansen & Hard, 1980). This is also the case for exploratory behavior, which has been reported to increase in the first weeks of life in mice (Ricceri, Colozza, & Calamandrei, 2000) and in silver foxes (Belyaev, Plyusnina, & Trut, 1984, 1985). In dogs, increased responsiveness toward human presence between 5 and 8 months of age has been reported by Goddard and Beilharz (1984).

Early development of fear reactions and reactions to humans has been studied less in precocial mammals such as farm animals. In sheep, some studies have looked at how reaction to humans develops, but the results appear to be contradictory. When animals were subjected to test situations which involved isolation with or without a surprise effect or human presence, 3- to 4-month-old lambs presented more fear reactions than those aged 5–6 months (Viérin & Bouissou, 2003). In older sheep, an age-dependent decrease in withdrawal reactions or number of vocalizations in the presence of a human has been reported from weaning to 20 months (Kilgour, 1998; Lankin, 1997). The intra-situation consistency seems to depend on age: for example, Jensen et al. (1999) repeatedly tested calves in an open-field test at the ages of 2, 10, and 25 weeks. These authors demonstrated that there was no correlation between individual differences at 2 weeks and individual differences at 10 or 25 weeks. By contrast, vocalizations and number of squares entered were positively correlated between 10 and 25 weeks. Similarly, Van Reenen et al. (2004) repeatedly tested heifer calves at 3, 16, and 29 weeks of age in four behavioral tests: an open-field test, exposure to a stationary human, a novel object test, and a restraint test. Again, consistency of individual differences increased with increasing age (a higher proportion of significant rank correlations between 16 and 29 weeks of age than between 3 and 16, and 3 and 29 weeks).

The study of fear reactions and reactions toward humans in farm animals is of interest because they can lead to handling problems and, when intense or chronic, to a state of stress which can be detrimental to the animal's welfare. They could also affect various aspects of behavior and productivity, for example, maternal behavior, reproduction potential, milk production, and resistance to disease (for reviews: Boissy & Bouissou, 1988; Rushen, Taylor, & de Passillé, 1999). Strong fear reactions or difficult relationships with humans can make horses unsuitable for riding and could potentially lead to accidents. Furthermore, fear reactions have been shown to impair the learning ability of horses (Fiske & Potter, 1979; Heird, Whitaker, Bell, Ramsey, & Lokey, 1986; Le Scolan, Hausberger, & Wolff, 1997). However, the development of fear responses in horses from an early age and their consistency between situations and over time have not been studied. Understanding the development of foals' fear reactions and reactions to humans could have at least two practical applications. The first is the possibility of predicting future behavior and identifying at what age this behavior can be accurately predicted. The second is to develop better methods of handling young animals and to familiarize them with a variety of stimuli.

The aim of this study was to examine the development and consistency of young foals' reactions to humans and of two characteristics related to fearfulness: propensity to react to novelty and to suddenness (startle response). We examined the approach or avoidance reactions to a human, a novel object and a sudden stimulus. Two different experiments were designed, using different animals. In the first, we examined whether the behavioral reactions studied were expressed from a very young age or emerged progressively over time. Three independent groups of foals were tested at 3, 12 or 24 weeks of age to avoid habituation to the test situations. The second experiment was a longitudinal study of a fourth group of animals, from 3 to 24 weeks of age. The purpose of this experiment was to determine whether the behavioral reactions remained constant across situations and over time once they had appeared.

MATERIALS AND METHODS

Experiment 1: Comparison of Three Independent Groups of Animals Tested at Different Ages

Animals. Twenty-seven Welsh foals (15 males and 12 females) born in June 2003 were studied before weaning. They were born outdoors without human assistance. At 1 day of age, they were individually identified with ear tags. They were kept outdoors as a single group with their mothers throughout the experiment. Outside the test periods, the foals were not handled and received the minimum human contact necessary for routine husbandry. They were weaned at 26 ± 2 weeks of age.

Experimental Group. Foals were randomly allocated to one of three experimental groups. Each group comprised 5 males and 4 females. The first group was tested at 3 weeks of age ± 1 day, the second group at 12 weeks of age ± 2 days, and the third group at 24 weeks of age ± 3 days (Fig. 1).

Test Procedure. All the test situations took place in a test pen (6 m $\times$ 6 m) delimited by 1 m-high metal hurdles placed in the pasture where the animals were living. Mares and foals could enter the test pen at any time and sniff the hurdles so that they would not react when they had to enter the pen for the tests. The pen was divided into nine sectors of equal size by a grid marked on the floor with white powder (Fig. 2). Tests were carried out by the same experimenter and helper (see below), who were used to working with horses but not involved in animal husbandry activities. At the beginning of the test, the mare was caught by the helper, fitted with a halter and led to the pen, followed by her foal. The helper held the mare in a corner of the pen (all mares in the same position) during the whole test to avoid distressing the unweaned foal and to minimize the influence of the mare's behavior on the test results. The mares could not be tethered because the test pen was constructed with light hurdles. All the mares were calm and remained immobile.

Foals were successively subjected to the following three situations:

Human approach. The test was similar to those used with horses by Søndergaard and Halekoh (2003) and Lansade, Bertrand, Boivin, and Bouissou (2004). The experimenter entered the pen and approached the foal slowly (approximately one step per second) with arms by her sides. If the foal was immobile when the experimenter was within a 1-m range, she slowly attempted to touch a part of its body and then to put her hand on its forehead for 2 s. The maximum time allowed for this test was 3 min.

We then used two fear-inducing situations: novel object exposure and a surprise effect, as conventionally used in many

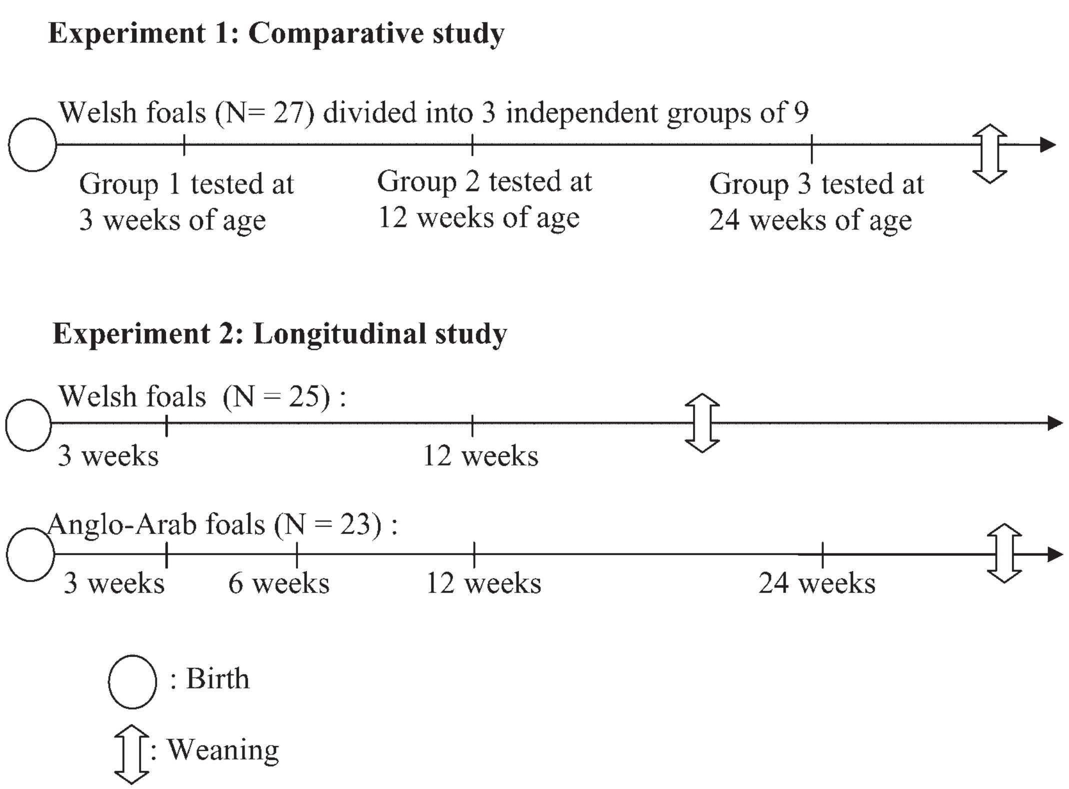

FIGURE 1 Experimental schedule.

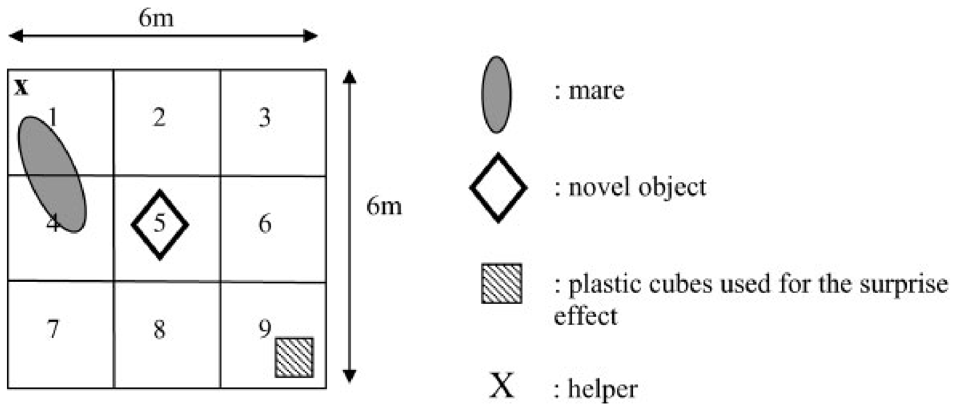

FIGURE 2 Test pen.

species (for review: Boissy, 1998), including horses (Lansade et al., 2004; Le Scolan et al., 1997; Viérin et al., 1998; Visser et al., 2001).

Novel object exposure. The experimenter introduced an unfamiliar object (two tires one on top of the other, diameter: .60 m; height: .40 m) into the center of the pen (sector 5) for 5 min. The object was placed 1 m from the mother so that the foal could approach the object while remaining in close proximity to its mother, minimizing the influence of the foal–mare bond.

Surprise effect. A pile of three yellow plastic cubes (.60 m × .60 m × .60 m) had been permanently placed in the pasture near the water bowl, in order to familiarize animals with them. During the test, this familiar object was introduced into sector 9 for 2 min. At the end of the 2 min, and when the foal was in sector 1 between his mother and the cubes, the pile was suddenly pulled over by a hidden experimenter by means of a long string attached to the bottom of the pile.

Behavioral Patterns Recorded in the Three Situations. It has been suggested that the magnitude of an animal's approach/avoidance response to a stimulus in standard test situations is indicative of fear of this stimulus (Barnett, Hemsworth, & Newman, 1992; Hemsworth, Barnett, & Jones, 1993). Thus, in the human approach situation, we measured the time required to put a hand on the foal's forehead. In the novel object exposure situation, we measured the number of contacts with the stimulus (number of behaviors associated with an investigative approach of the object: nibbling, sniffing with contact, licking, kicking . . . these behaviors are different, but are generally classed in the same category of the horse ethogram, namely object manipulation, e.g., McDonnell & Poulin, 2002). In the surprise effect test, the flight distance (distance between the stimulus and the foal, measured immediately after the startle response) was estimated using the lines marked on the floor of the pen.

Other behaviors, such as locomotor activity, position in the test pen, sniffing, vocalizations, etc. were recorded. However, these were not expressed sufficiently or the variability between individuals was not sufficient to be used for statistical analyses.

Experiment 2: Longitudinal Study

Animals. The experiment was carried out with two different groups of horses, living in two different places. The first group consisted of 23 Anglo-Arab foals (10 males and 13 females) born in April and May 2002, and the second of 25 Welsh foals (11 males and 14 females) born in June and July 2002. The Anglo-Arab foals were born indoors and stayed there for the first day of life. The Welsh foals were born outdoors, without human assistance. Animals of both groups were kept outdoors with their mothers until weaning, and received the minimum human contact necessary for routine husbandry. Welsh foals were weaned at 20 ± 4 weeks of age and Anglo-Arab foals at 26 ± 2 weeks of age.

Test Procedure. In both groups, foals were tested at 3 and 12 weeks of age. Anglo-Arab foals were additionally tested at 6 and 24 weeks of age (Fig. 1). Welsh foals could not be tested at 6 weeks for technical reasons, or at 24 weeks because they were already weaned by that time. The test procedures were the same as those described in the first experiment. However, in this experiment, for the novel object exposure situation, the object was changed for each test in order to be ''novel'' every time. We used a blue plastic cube (.60 × .60 × .60 m), an orange and white road sign cone (.40 m in diameter, .65 m in height), a coiled yellow hose pipe (.80 m in diameter, .40 m in height), and a roll of black plastic (.50 m in diameter, .65 m in height) at 3, 6, 12, and 24 weeks of age, respectively.

Statistical Analysis. As many foals could not be touched by the experimenter, did not touch the object or did not flee during the surprise effect, the data for each variable were transformed into qualitative categories: expression of a behavioral response was coded ''1;'' absence of expression was coded ''0.'' These categories are: the foal expressed (*coded 1*)/did not express (*coded 0*) an avoidance reaction to the human approach (possible/impossible to put a hand on the forehead within 3 min); the foal touched (*coded 1*)/did not touch (*coded 0*) the object; and finally, the foal expressed (*coded 1*)/did not express (*coded 0*) an avoidance reaction (startle response) during the surprise effect test (stayed on the spot or moved to a different place).

Experiments 1 and 2. Logistical regression (SAS/TAT, 1999) allowed testing for a global effect of age, sex, and the interaction of age and sex. However, logistical analyses were not always possible due to the structure of the data. At some ages and for some variables, no variability was observed between animals. Consequently, in the first experiment, only Chi-2 could be used and the sex factor was not therefore considered, but the number of males and females who expressed a reaction is presented in the figures. In the second experiment, the data for Anglo-Arab and Welsh foals were analyzed separately since they were not bred and tested at the same place. Test ages with no variability were removed in order to perform the logistical analyses on the other ages (Falissard, 1998). After logistical regression, if age factor was significant, sign tests (Siegel, 1956) were used to compare the change between two ages.

The consistency across animal responses to two situations at the same age (inter-test consistency—*experiment 1 and 2*) or the consistency across animal responses in the same situation but at two different ages (intra-test consistency—*experiment 2*) was examined. For that purpose, Fisher exact probability tests were used to compare the proportion of consistent animals between two tests or two ages to the random probability of .5.

Experiment 2. In experiment 2, we also tested the hypothesis that once a behavioral response was observed, it would systematically be observed later. For example, the four tests for Anglo-Arab animals included responses ranging from 0000 (no occurrence of the behavioral reaction) to 1111 (occurrence at each test session). To test our hypothesis, we compared the observed and random proportions of occurrences. Two combinations were excluded: when "1" never appeared (0000) or only appeared at 24 weeks of age (0001), as neither provided relevant information to test our hypothesis. Thus, there were 14 possible combinations of responses for the four test ages for the Anglo-Arab foals (from 0010 to 1111). Two could also have been observed for the two test ages for the Welsh foals (10 or 11). These combinations were allocated into two categories: combinations which never involved "1-0" successions (category A such as 0011, 0111, 1111 or 11) and others (category B such as 1000, 0101..., or 10). The observed proportions of categories A and B were respectively compared to the random proportions (Anglo-Arab: 3/14 and 11/14; Welsh: 1/2) with a Fisher's exact test (Siegel, 1956).

Finally, we examined whether there was a relationship between the ages at which behavioral reactions in different situations emerged. For that, Fisher exact probability tests were used to compare the proportion of animals whose first reactions to two different situations emerged at a same age (e.g., the first reaction to an object and to humans emerged both at 3 weeks) to the random probability of .5.

RESULTS

Experiment 1: Comparison of three Independent Groups of Animals Tested at Different Ages

Human Approach Significantly more foals avoided the human in the group tested at 12 weeks than in the group tested at 3 weeks of age ($\chi^2 = 4.00$; $p < .05$, Fig. 3). Similarly, significantly more foals avoided the human in the group tested at 24 weeks than in the group tested at 12 weeks of age ($\chi^2 = 5.14$; $p < .05$) or than in the group tested at 3 weeks of age ($\chi^2 = 14.40$; $p < .001$, Fig. 3).

Novel Object Exposure Significantly more foals touched the novel object in the group tested at 24 weeks of age than in the group tested at 3 or 12 weeks of age (*3 weeks vs. 24 weeks:* $\chi^2 = 8.10$; $p < .01$; *12 weeks vs.24 weeks:* $\chi^2 = 10.89$; $p < .001$; Fig. 4). There was no significant difference between the groups tested at 3 and 12 weeks of age ($\chi^2 = .40$; NS).

Surprise Effect Three foals out of nine had an avoidance reaction toward the surprise effect at 3 and 12 weeks of age, whereas five out of nine had this reaction at 24 weeks of age, but the differences were not statistically significant ($p > .1$, Fig. 5).

Whatever the test, Figures 3–5 show no sex effect, but the number of males and females in each group was not sufficient to be statistically compared. No consistencies across situations were found.

Experiment 2: Longitudinal Study

Comparison of the Behavior of the Same Animals Tested at Different Ages

Logistical regression

Human approach. Whatever the breed, the logistical regression showed an effect of age ($p < .01$), but no effect of sex or interaction between sex and age.

Novel object exposure. In Anglo-Arab foals, there was no variability at 3 weeks of age, so we could not consider this age in the logistical regression. After removing this age, there was no effect of sex, but an effect of age ($p < .01$) and an effect of interaction between sex and age ($p < .05$).

In Welsh foals, there was only an age effect ($p < .01$).

Surprise effect. In Anglo-Arab foals, after removing the age of 24 weeks (due to an absence of variability), there was no effect of age, sex or interaction between sex and age.

Similarly there was no effect for these parameters in Welsh foals.

Sign test

Human approach. Significantly more avoidance reactions toward humans emerged (0-1) than disappeared (1-0) between 3 and 12, 3, and 24, and 6 and 24 weeks of age in Anglo-Arab foals (Tab. 1a), and between 3 and 12 weeks of age in Welsh foals (Tab. 1b).

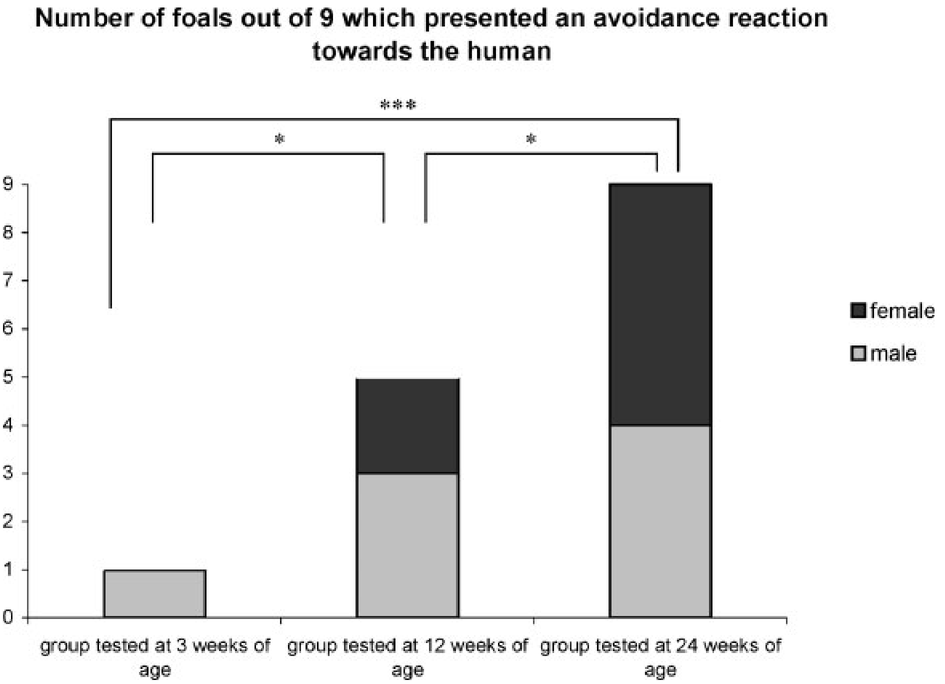

FIGURE 3 Comparative study, human approach.

For technical reason, one Welsh foal could not be tested during the human approach test performed at 12 weeks of age.

Novel object exposure. Significantly more touch reactions toward the novel object appeared than disappeared between 3 and 12, 3 and 24, 6 and 12, 6 and 24, and 12 and 24 weeks of age in Anglo-Arab foals (Tab. 1a), and between 3 and 12 weeks of age in Welsh foals (Tab. 1b)

Surprise effect. In Anglo-Arab foals, more startle reactions during the surprise effect test appeared than disappeared between 3 and 12 (tendency, $p < .1$), 3 and 24,

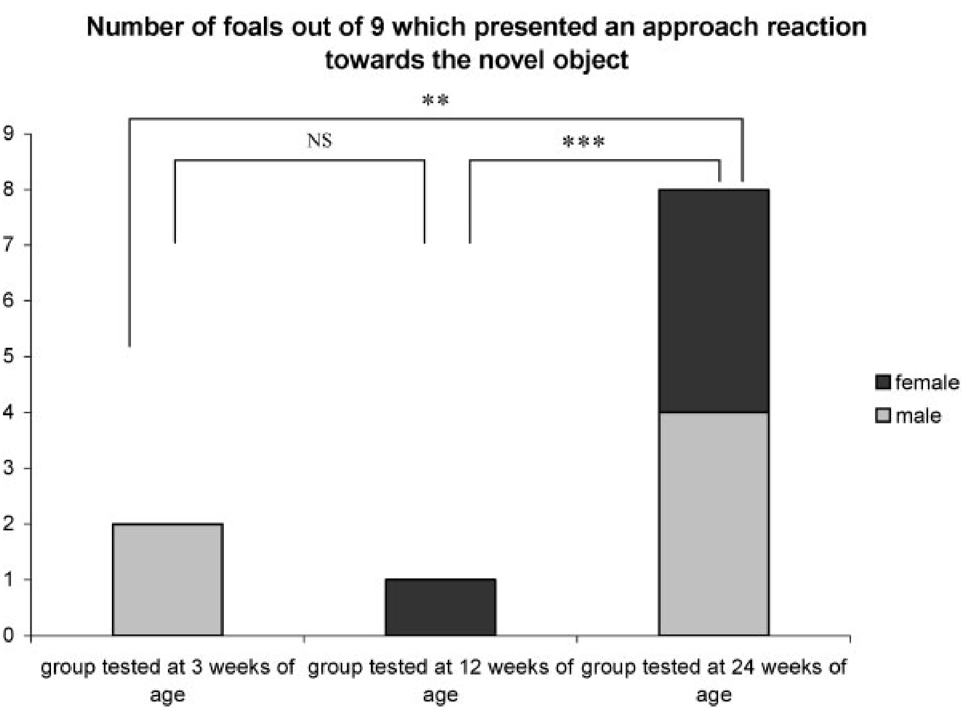

FIGURE 4 Comparative study, exposure to novel object.

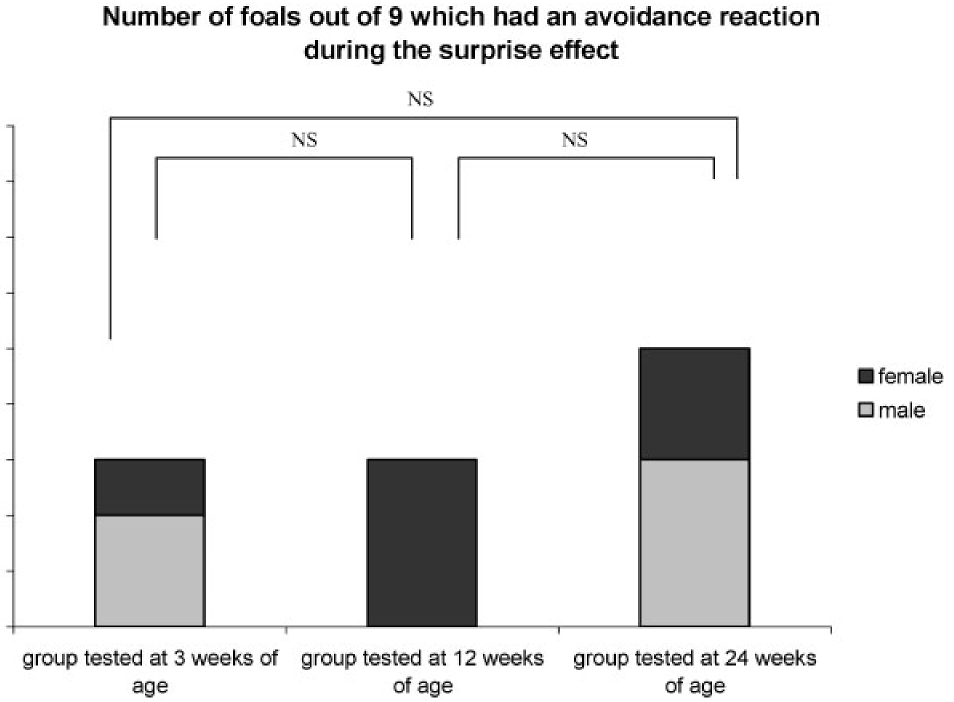

FIGURE 5 Comparative study, surprise effect.

6 and 24, and 12 and 24 weeks of age (Tab. 1a). In Welsh foals, the difference between the number of appearances and disappearances of the behavior was not significant (Tab. 1b)

Stability of Behavior Over Time

Fisher's exact test

Human approach. In Anglo-Arab foals, the reactions were constant only between 6 and 12, 12 and 24, 3 and 12 weeks of age (Tab. 2a).

In Welsh foals, the reactions were not constant (Tab. 2b).

Novel object exposure. In Anglo-Arab foals, it was impossible to test the consistency with 3 weeks of age since there was no variability at this age. The reactions were not constant between the other ages (Tab. 2a).

In Welsh foals, the reactions were not constant (Tab. 2b).

Surprise effect. In Anglo-Arab foals, it was impossible to test the consistency with 24 weeks of age since there was no variability at this age. The reactions were constant between 3 and 6, and 6 and 12 weeks of age (Tab. 2a).

In Welsh foals, the reactions were not constant (Tab. 2b).

Comparison between combinations which never involved "1-0" (category a) and others (category b). (*As explained in Materials and Methods section, we did not examine the combinations of responses where "1" never appeared or only appeared at 24 weeks of age*)

Human approach. Compared to the random proportions, there were significantly more individuals (Anglo-Arab: $p < .01$ Fig. 6a; Welsh: $p < .05$ Fig. 6b) who maintained the avoidance reaction toward a human after it had been first observed (Anglo-Arab: 9/10; Welsh: 7/8) than individuals who did not (Anglo-Arab: 1/10; Welsh: 1/8).

Novel object exposure. Compared to the random proportions, there were more Anglo-Arab foals who maintained the touch reaction to the novel object ($p = .05$ Fig. 7a) after it had been first observed (7/9) than individuals who did not (2/9).

Three Welsh foals showed a touch reaction and maintained it after it had been first observed and none did not maintain it, but the numbers were too low to be statistically significant (Fig. 7b).

Surprise effect. Compared to the random proportions, there were significantly more Anglo-Arab foals ($p < .001$ Fig. 8a) who maintained the startle response once it had been observed (16/18), than foals who did not (2/18).

Eight Welsh foals were consistent in their response to this test, but 7 were not (Fig. 8b). Compared to the random proportions, the difference was not statistically significant.

Table 1. Comparison of the Behavior of the Same Animals Tested at Different Ages in Anglo-Arab (Sign Test) and Welsh foals (Sign Test)

Test	Possibilities	Ages (Weeks) 3 vs. 6	6 vs. 12	12 vs. 24	3 vs. 12	3 vs. 24	6 vs. 24
(a) Anglo-Arab foals (sign test)							
Human approach	N° of 01	2	5	5	6	11	10
	N° of 10	1	0	0	0	0	0
	Value of ε	NT	NT	NT	2,45	3,32	3,16
	p-value				*	***	**
Exposure to novel object	N° of 01	2	7	9	9	16	14
	N° of 10	0	0	2	0	0	0
	Value of ε	NT	2,65	2,11	3	4	3,74
	p-value		**	*	**	***	***
Surprise effect	N° of 01	4	3	7	7	12	8
	N° of 10	0	2	0	2	0	0
	Value of ε	NT	NT	2,65	1,67	3,46	2,83
	p-value			**	$p < .1$	***	**

(b) Welsh foals (sign test)	Possibilities	Ages (Weeks) 3 vs. 12
Human approach	N° of 01	11
	N° of 10	1
	Value of ε	2,89
	p-value	**
Exposure of novel object	N° of 01	10
	N° of 10	0
	Value of ε	3,16
	p-value	**
Surprise effect	N° of 01	7
	N° of 10	5
	Value of ε	0,58
	p-value	NS

Possibility "01": the behavioral reaction disappears between two ages.
Possibility "10": the behavioral reaction appears between two ages.
*$p < .05$.
**$p < .01$.
***$p < .00.1$.
NT, "Non Tested," there were not enough animals to test the comparison.

Stability Across Situations (Fisher's Exact Test) Whatever the age or breed, there was no relationship between the three tests.

Relationship between the Ages at Which the Behavioral Reaction Appeared in Different Tests There was no relationship in either breed between the times when reaction to humans and to novel objects or to startle response appeared.

DISCUSSION

The first aim of this study was to examine whether behavioral reactions to humans, novelty, and suddenness are expressed by very young foals or appear progressively with age. The behavioral reactions of foals were thus compared at different ages between birth and weaning, using tests conventionally reported to provoke fear reactions in many species including horses, namely novel and sudden stimuli (for review: Boissy, 1998), in which approach or avoidance reactions were recorded. In almost all species, approach or contact with a stimulus is generally considered as indicative of absence of fear, whereas avoidance is often considered as a possible indicator of fear (e.g., Barnett et al., 1992; Hemsworth et al., 1993; Jones, 1995 in poultry; Vandenheede et al., 1998; Viérin & Bouissou, 2001 in sheep and Lansade et al., 2004; Viérin et al., 1998 in horses). The results of the first experiment (comparative study of

Table 2. Comparison of the Behavior of the Same Animals Tested at Different Ages in Anglo-Arab (Fisher test) and Welsh foals (Fisher Test)

Test	Possibilities	Ages (Weeks) 3 vs. 6	6 vs. 12	12 vs. 24	3 vs. 12	3 vs. 24	6 vs. 24
(a) Anglo-Arab foals (Fisher test)							
Human approach	p-value	NS	**	**	*	NS	NS
Exposure to novel object	p-value	NT	NS	NS	NT	NT	NS
Surprise effect	p-value	**	*	NT	NS	NT	NT

(b) Welsh foals (Fisher test)

Test	Possibilities	Ages (Weeks) 3 versus 12
Human approach	p-value	NS
Exposure to novel object	p-value	NS
Surprise effect	p-value	NS

*$p < .05$.
**$p < .01$.
***$p < .001$.
NT, "Non Tested," there was no variability between animals to test the comparison.

three independent groups tested at different ages) clearly indicated that foals increasingly touched novel objects and avoided human contact between 3 and 24 weeks of age, whatever the sex. These results were corroborated by the results of the second experiment (longitudinal study). By contrast, there was no significant change in the startle response in the first experiment, whereas in the second experiment we observed that Anglo-Arab foals showed an increasing startle response. Reactions to novelty and human approach and to some extent startle responses were expressed by few individuals at a very young age and appeared progressively with age.

This study contributes to a better knowledge of the ontogeny of behavioral reactions in a precocial mammalian species. The progressive appearance of approach or avoidance reactions with age in horses is in line with reports of the development of behavior patterns in altricial mammals, for example, freezing in rats (Hansen & Hard, 1980), exploratory behavior in silver foxes (Belyaev et al., 1984, 1985), and avoidance reactions to unknown stimuli in domestic chicks (Andrew & Brennan, 1983; Bateson, 1964; Salzen, 1979).

Our results raise the question of why the horses increasingly avoided human approach, and to some extent sudden stimuli, but approached novel objects. In fact, the test situations were such that only avoidance reactions could be observed in the human and surprise effect tests and only approach reactions in the novel object test. One explanation may be that young foals express few specific reactions toward their environment (e.g., approach or avoidance). As foals get older, these reactions gradually appear. This could be explained by a differential stimulus appraisal according to age. Another possible explanation is that the reactions of avoiding humans and approaching a novel object are caused by two different motivations, fear in the case of humans, exploration or curiosity in the case of novel objects, the former leading to avoidance, the latter to approach. Finally, the absence of approach or avoidance reactions may not necessarily mean fear or absence of fear, but simply indifference toward the stimulus. Several hypotheses may be offered to explain why approach and avoidance reactions are not expressed at a young age but appear with time: a change in the mare-foal bond, a change in the mother's behavior, a process of maturation or the effect of experience.

In follower species, the survival of the young depends on its capacity to follow its mother. The mare-foal bond is very strong when the foal is young, and then decreases progressively (Carson & Wood-Gush, 1983; Houpt, 2002). At 3 weeks of age, and to some extent at 12 weeks, foals remain in close proximity to their mothers who represent safety, which may explain why they were easier to touch, did not approach the novel object and did not flee far from the mother during the surprise effect test. Nevertheless, we observed that the average distance between the mares and their foals at pasture at 3 weeks of age was 3.40 ± 2.06 m (unpublished observations of the horses in the present study). This distance would have allowed foals to touch the novel object (placed 1 m from the mother), to avoid human contact or to take flight during the surprise effect test as early as 3 weeks of age while remaining relatively close to their mother. Therefore, this hypothesis cannot totally explain the absence of

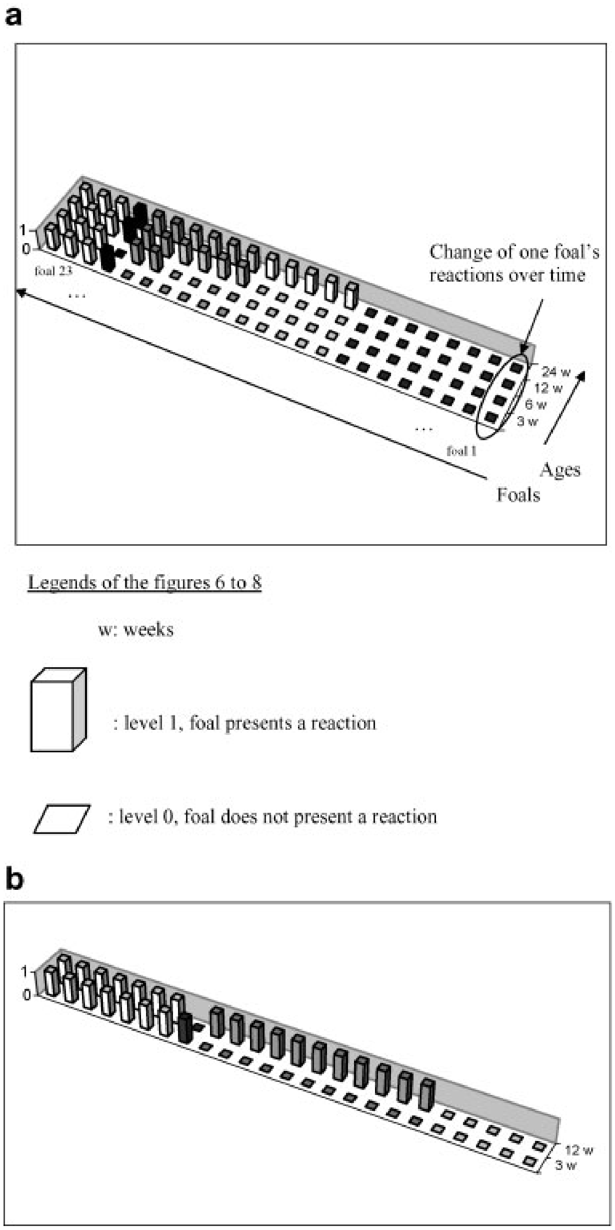

FIGURE 6 (a) Longitudinal study, human approach, Anglo-Arab foals. (b) Longitudinal study, human approach, Welsh foals.

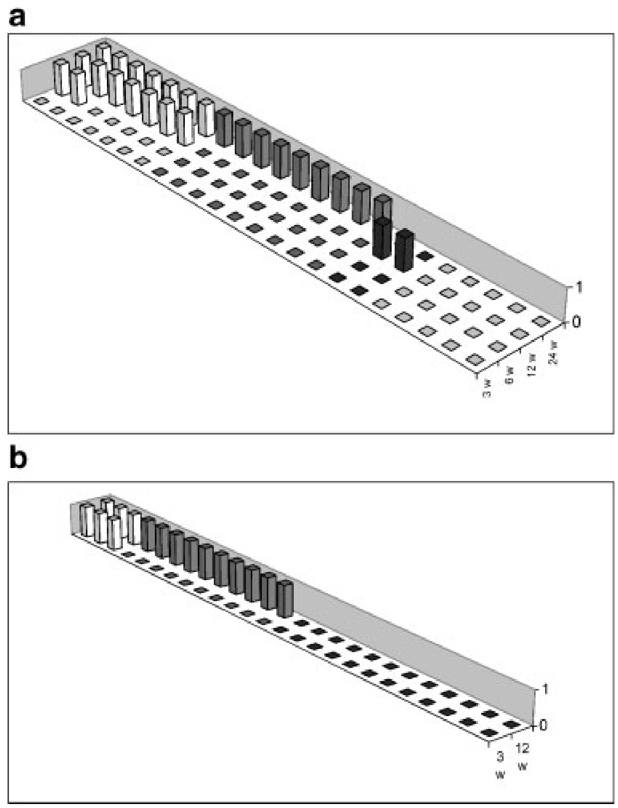

FIGURE 7 (a) Longitudinal study, exposure to novel object, Anglo-Arab foals. (b) Longitudinal study, exposure to novel object, Welsh foals.

reactions. Another possible explanation is that very young foals closely adopt their mothers' behavior, and as the mares in our tests were held immobile, this could be why the foals did not show any approach or avoidance reaction. With the decrease of the mare–foal bond over time, the foals tended to react more and more independently (approach or avoidance), even though the mother was still held immobile. This absence of reaction to potentially dangerous events observed in our experiment raises the question of whether or not very young foals can react alone to potentially dangerous events in the absence of their mother or other adults. Studying artificially reared subjects would help answer this question, but this type of rearing is rare in foals.

Changes in the mother's behavior as her offspring gets older could influence the foal's behavior. However, all the mares remained calm and immobile throughout the tests. We cannot exclude the possibility of olfactory communication of stress from mare to foal. However, the mare was probably less and less stressed by the test situation and by the distance of the foal as it got older. This could partly explain the increasing number of approach reactions observed in the foals, but not the increasing avoidance reactions.

The survival of the foal depends on the mare–foal bond and also on its belonging to the social group. Accordingly, very young animals may have a stronger reaction to social isolation than older individuals. In fact, very few studies have reported an age-dependent decrease in reaction to social isolation in gregarious mammals. Viérin and Bouissou (2003) found that 3- to 4-month-old lambs were more agitated and vocalized more during an isolation test than those aged 5–6 months. It could be of interest to test this finding in horses.

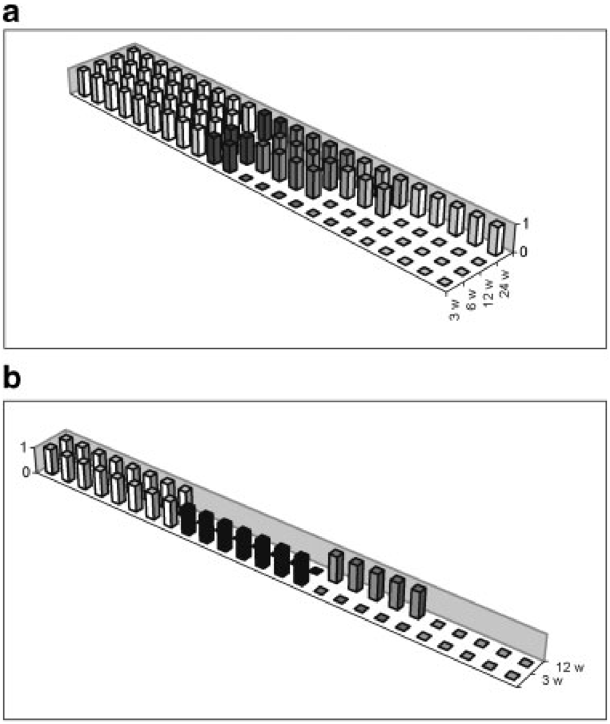

FIGURE 8 (a) Longitudinal study, surprise effect, Anglo-Arab foals. (b) Longitudinal study, surprise effect.

A process of maturation could also explain the gradual appearance of the behavioral reactions. Maturation could affect levels of perception, internal state or responsiveness. Young animals may or may not perceive the attributes of a stimulus (e.g., novelty). If they do, their internal state (e.g., motivation, emotion, etc.) may or may not change, which may or may not elicit a reaction (approach or avoidance). Ricceri et al. (2000) suggested that perception in mice is immature, since preweaning mice are unable to detect object novelty, suggesting immaturity in gathering spatial information. However, in precocial animals such as horses, sensory bases are known to be well-developed in the neonate.

Finally, even though the environment was controlled as much as possible in this experiment, the foals were confronted with many stimuli outside the test periods (interactions with conspecifics, confrontation with potentially frightening situations). Such experiences at a young age undoubtedly have an impact on the behavioral development of foals and could also explain the gradual appearance of approach or avoidance reactions during the tests.

The second aim of this study was to examine the stability across situations and over time of behavioral reactions.

Whereas stability of reactions in suddenness, novelty, and sometimes human tests is frequently reported in older animals (cattle: Boissy & Bouissou, 1995; de Passillé et al., 1995; sheep: Romeyer & Bouissou, 1992; Vandenheede et al., 1998; horses: Lansade et al., 2003; Viérin et al., 1998; Wolff, Hausberger, & Le Scolan, 1997; for a review: Boissy, 1998), it was not observed in this study. Two hypotheses can be proposed to explain this.

First, at a very young age, the reactions observed in the three tests could be mediated by different underlying traits such as curiosity (in the case of the novel object test), fearfulness (in the case of the surprise test), and a specific reactivity to humans (in the case of the human test). With ageing, the stimulus appraisal can change, and reactions to certain stimuli, for example objects and surprise, could be mediated by the same underlying trait, for example fearfulness, as reported in many studies. The lack of inter-test consistency could also be due to a high degree of fear response specificity in young foals, that is, foals could be fearful of novelty but nonfearful of humans or vice versa.

Second, the lack of inter-test consistency at a very young age could also be due to the progressive appearance of reactions with time: only a few animals present an approach or avoidance reaction when very young. In addition, the behavioral reactions of approach or avoidance to a given stimulus emerge at different times in different individuals and there is no correlation between the emergence times of reactions to humans and novel objects or the startle response. This lack of correlation between emergence times could also explain the lack of correlation between tests at a very young age.

The results also show a lack of consistency of responses over time, which is probably due to the gradual appearance of responses with time. However, a more specific statistical analysis showed that once foals manifested a behavioral reaction (approach or avoidance) to a given stimulus at a given age, in most cases they continued to manifest the same reaction later, at least until weaning. Thus, it would theoretically be possible to predict temperamental traits as soon as they have been expressed through a behavioral response. However, as temperamental traits are rarely expressed through behavioral reactions at a very young age, the global predictive value of these reactions is generally low in very young animals, but increases with age. This is in line with data obtained in other mammalian species. Individual differences in behavior have a poor or moderate consistency early in ontogeny but increase in adults (calves: Jensen et al., 1999; Van Reenen et al., 2004; wolves: McDonald, 1983; dogs: Goddard & Beilharz, 1984; pigs: Janczak, Pedersen, & Bakken, 2001; Ruis et al., 2000), and the same trend has been observed in humans (reviewed by Zuckerman, 1991).

Finally, we did not observe an effect of sex on behavioral responses or when these appeared (except an effect of the interaction of sex and age in the novel object test performed during the longitudinal study on Anglo-Arab foals, which has no clear explanation). The fact that animals were not yet sexually mature in this experiment may explain this quasi-absence of sex effect on reactions.

To conclude, this study contributes to the description of the ontogeny of some aspects of fear reactions and reactions toward humans in a precocial mammal. It suggests similarities with altricial species, but the underlying mechanisms have not yet been explored and require further study. From a practical point of view, our results have two consequences. First, as very young foals presented very low avoidance reactions, especially toward humans, they may be easier to handle, which could be used to familiarize them with a variety of stimuli. Second, as approach or avoidance reactions toward specific stimuli were not observed in very young foals, as a general rule it is probably not appropriate to try to select foals on the basis of their behavior before weaning.

NOTES

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Fearfulness in horses: A temperament trait stable across time and situations

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Abstract

The purpose of this study was to test the existence of a ''fearfulness'' trait in horses, by testing the stability across situations and over time of the responses to different fear-eliciting situations. It was also to identify which behavioural parameters are the best indicators of this trait. Sixty-six Welsh ponies and 44 Anglo-Arab horses were successively tested at 8 months and 1.5 years of age. Of these, 33 Welsh ponies and 21 Anglo-Arabs were also tested at 2.5 years of age. At each age, they were subjected to four test situations. The first test involved the introduction of a novel object in the test pen (novel object test). In the second test, a novel area was placed in the pen between the horse and a bucket of food, to determine the time the horse took to cross the area (novel area test). Finally, the third test consisted in suddenly opening an umbrella in front of the horse while it was eating (surprise test). During these tests, many behavioural parameters were recorded. A fourth test consisted of a surprise test during which the horse was held by a handler while its heart rate was measured. Spearman correlations were used to identify links between behavioural parameters measured during different tests and between different ages.

Reactions to the first three tests showed consistency between them and over time. Among all the behavioural parameters measured during these tests, some presented high stability over time and were well correlated with behaviours expressed during other tests, indicating they are the best indicators of a fearfulness trait: the frequency of licking/nibbling the novel object, the time to put one foot on the novel area and to eat from a bucket placed just behind it, and the flight distance and the time to eat under the opened umbrella. The stability across responses expressed in various fear-eliciting events and over time from 8 months to 2.5 years of age suggests the existence of a 'fearfulness' trait in horses.

The different indexes of heart rate measured or calculated during the surprise effect present limited stability over time and almost no correlation with the behavioural parameters measured during the other

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three tests. We conclude that, in contrast to the previously mentioned behaviours, these are not reliable measures of a temperament trait.

From a practical point of view, this study shows that it is possible to identify a horse's level of fearfulness as early as 8 months of age using the first three tests.

Keywords: Horse; Temperament; Fearfulness; Novelty; Suddenness; Behavioural tests

1. Introduction

The behavioural reactions expressed by individuals confronted with particular situations are strongly affected by their temperament. Temperament is generally considered as a set of behavioural tendencies, present early in life and relatively stable across various kinds of situations and over the course of time (Bates, 1987; Goldsmith et al., 1987). This stability means that an individual's behaviour in specific situations is predictable to a certain extent. Fearfulness is considered as one of the basic traits of an individual's temperament. While fear is an emotional state induced by the perception of actual danger (for a review, see Forkman et al., 2007), fearfulness can be defined as a predisposition to react in a similar manner to various fear-provoking events. Fearfulness can be inferred from the behavioural states expressed by the individual in potentially frightening situations. It has been frequently studied in farm animals as it influences many other behaviours, such as social interactions, maternal behaviour or learning ability, as well as productivity and welfare (for reviews, see Bolles and Fanselow, 1980; Gray, 1987; von Borell, 1995; Jones, 1996; Rosen and Schulkin, 1998; Boissy, 1998; McMillan, 1999; Maestripieri, 1999; Erhard and Schouten, 2001).

In horses, temperament can strongly determine the animal's usability. Buckley et al. (2004) conducted interviews with Pony Club members and concluded that a horse's temperament (quietness, reliability, safety) is the most important characteristic of a Pony Club horse, before its size, soundness, purchase price, etc. Excessive fear reactions limit the use of horses in many situations, and can even, in certain cases, render the horse dangerous. On the other hand, an excessively low level of fearfulness may be inconvenient in some equestrian disciplines, even if this aspect has so far attracted little attention. Consequently, the development of tests to assess a horse's temperament early in life, and particularly a possible fearfulness trait, would be particularly useful. For this purpose, it is necessary to explore the stability of the individual's reactions over time and in different frightening situations.

Stability of fear reactions over time has been reported in many species (for a review: Forkman et al., 2007). In post-weanling horses, Visser et al. (2001) reported a short-term consistency (1 month) of behaviour during a novel object test conducted at 9 and 20 months of age, but found that only a few behavioural parameters showed consistency between 9 and 20 months of age. Therefore, to our knowledge, the long-term consistency of fear reactions has never been convincingly demonstrated in the horse.

The search for stability of fear reactions across situations has also been reported (for a review: Forkman et al., 2007). This requires the observation of a number of individuals in various potentially frightening situations. In horses, Wolff et al. (1997) found correlations between two neophobia tests: an unknown object test and a bridge test, suggesting the existence of a trait of fearfulness. Using open-field tests, some authors have described correlations between reactions to novelty, to suddenness and to social isolation, and concluded the existence of a general trait of 'fearfulness' (e.g. sheep: Romeyer and Bouissou, 1992; Vandenheede et al., 1998; Viérin and Bouissou, 2003; horses: Viérin et al., 1998). However, in these cases a bias exists, since the correlations were established between situations involving different stimuli, but all involving some common fear-inducing element, such as social separation or novelty of the pen. The correlations may thus have been due to these common elements. In the present study, we chose to test the animals in an environment which does not provoke any particular fear reactions apart from those to the tested stimulus: horses were tested in a familiar environment, in the presence of conspecifics, and after a period of habituation to the test procedure. In this way, there were theoretically no common elements (such as social separation or novelty of the test pen) between the different tests.

Fear states can be expressed through behavioural responses, but also through physiological changes, and many studies have used heart rate measurements to characterise fearfulness (for a review: von Borell et al., 2007). In horses, Visser et al. (2002) showed that heart rate variables measured during a novel object test and a handling test may quantify certain aspects of a horse's temperament, such as fearfulness, since these measures were consistent between 9 months and 21 months of age. It would be interesting to examine whether there is a relationship between behavioural states and heart rate observed during fearful situations. Measuring the heart rate to predict a horse's level of fearfulness may be useful in practice because it is non-invasive and is easy to use by a person inexperienced in behavioural observations.

The purpose of this study was to determine whether it is possible to infer a trait of fearfulness from the measurement of behavioural and physiological responses (heart rate) expressed by individuals confronted with specific frightening situations. For this purpose, we tested the two characteristics of a trait: stability over time and across situations. We tested the animals in two situations involving novelty and in two situations involving suddenness, and we repeated these situations every year, from 8 months to 2.5 years of age. Many behavioural and physiological parameters were recorded during these situations. The first step was to test the stability over time of these parameters by calculating correlations between parameters measured from 8 months to 2.5 years of age. The second step was to determine the stability across situations of the parameters: for each age, we calculated the correlations between parameters measured in the four different fear-inducing tests. These two steps also allowed us to identify the most reliable indicators of this trait, i.e. the behavioural or physiological parameters which show the best stability over time and across situations.

This paper is part of a more general study which attempts to assess several possible temperament traits in horses such as gregariousness (Lansade et al., 2008), reactivity to humans (Lansade and Bouissou, in press) or activity level (Lansade, 2005; Lansade et al., 2006).

2. Animals, material and methods

2.1. Animals

One hundred and ten horses were used, divided into four groups. They originally comprised 22 Anglo-Arab horses (AA01) and 33 Welsh ponies (W01) born in 2001, and a further 22 Anglo-Arab horses (AA02) and 33 Welsh ponies (W02) born in 2002. Of those, five horses had to be excluded from the study due to illness ($N = 2$) or following a bone fracture ($N = 3$). The number of horses tested at each age is presented in Table 1. The animals of the two breeds were born and lived in two different places.

All animals were maintained on pasture with their dam until 6 ± 1 months of age when they were weaned. Males were castrated around 12 months of age. The animals were housed indoors from 6 to 11

Table 1
Age and number of horses in the two different breeds (AA: Anglo-Arab; W: Welsh Pony) and two different birth years (01: 2001; 02: 2002) at the three test periods

	2002	2003	2004
AA01	8 months 22 (22)	1.5 years 21 (20)	2.5 years 21 (20)
AA02		8 months 22 (21)	1.5 years 19 (19)
W01	8 months 33 (26)	1.5 years 33 (33)	2.5 years 33 (21)
W02		8 months 33 (32)	1.5 years 32 (22)

The numbers in brackets represent the number of horses that had their heart rate measured in the surprise test.

months, 20 to 23 months, and 32 to 35 months, corresponding both to the winter period and the test periods. Outside these periods, they were kept on pasture.

The Anglo-Arab horses were housed individually on sawdust bedding, in a 6 m × 3 m box adjacent to an individual 3 m × 3 m outside area (Fig. 1). Boxes were separated from each other by metal hurdles so that the horses could see all the other animals in the barn and interact with their neighbours (sniffing, licking, biting or grooming, etc.). The outside area was separated from the inside area of the box by a door. When the horses were in the outside area and the door was closed, they could not see inside.

The Welsh ponies were housed together in a straw-bedded, 15 m × 15 m group pen and were moved to an outdoor paddock every day for 4 h.

All the test animals were fed twice a day with commercial pellets and hay, except for the test periods involving feeding motivation during which they were fed three times a day, so that all the animals had a similar level of feeding motivation whenever they were tested. Water was available ad libitum.

Outside the test periods, the animals were maintained on pasture. They received similar, limited human contact necessary for routine husbandry: feeding when indoors, changes of pasture and any emergency veterinary care.

2.2. Experimental procedure

In order to examine only the reactions specific to the stimulus studied, we attempted to test animals in a context as neutral as possible: tests were performed in a familiar place and animals were habituated to the experimental procedure for a minimum of 3 days immediately before the tests.

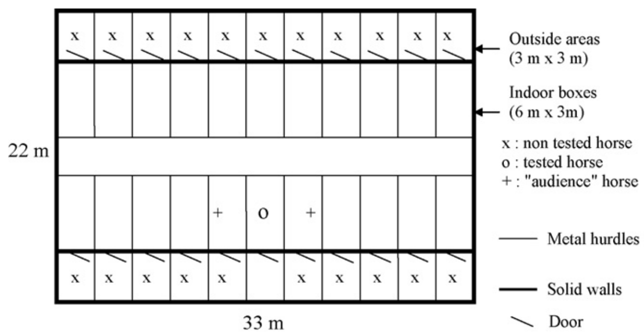

Fig. 1. Layout of the building where the Anglo-Arab horses were housed and tested.

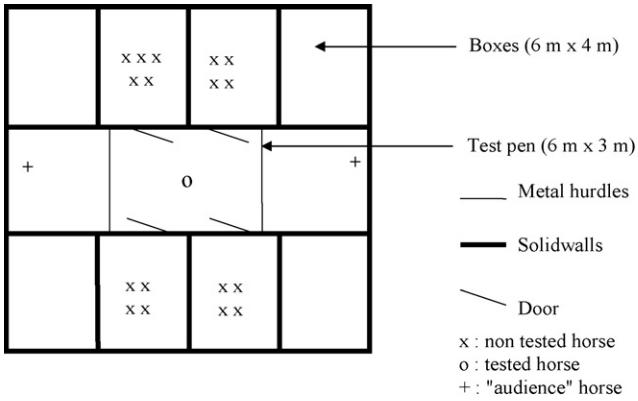

Fig. 2. Layout of the building where the Welsh ponies were housed and tested.

Anglo-Arab horses were tested in their own boxes while non-test horses were kept in their outside areas (Fig. 1). Welsh ponies were tested in a pen constructed in the corridor of a barn close to the pen where they lived (Fig. 2). In both cases, the test pens were 6 m long and 3 m wide. During the test period, the Welsh ponies were randomly moved, in groups of four or five, to four boxes (4 m × 6 m) adjacent to the test pen, for 4 h per day. In both breeds, when a horse was tested, it was moved by a handler from the outside part of its box (Anglo-Arab) or from its box (Welsh) and placed in the test pen, and the test began immediately. The other horses and the tested horse could not see each other.

Horses were randomly assigned to a testing order for each test. During the habituation phase and the different tests, the experimenters were hidden behind a one-way mirror. To avoid the test horse being alone in the pen during the habituation phase and the tests, two ''audience'' horses were attached at each side of the test pen, at a distance of about 3 m (Figs. 1 and 2). These were non-experimental animals and the same audience horses were always used for each group. They were unfamiliar to the test horses at the beginning of the study. They were chosen because they were known to be particularly calm and likely to stand still throughout the test period. They were habituated to the test situations before the experiment. During the tests, we also checked that they did not show any special reaction towards the fearful stimuli in the test pen.

2.2.1. Habituation to the test pen

This phase consisted of habituating the horse to being led into the test pen and to staying in it without any particular reaction. The test horses were placed in this situation daily for 5 min until they no longer manifested the following behaviours for three consecutives days: neighing, defecating, trotting or galloping. A single occurrence of one of these four behaviours during the three consecutives days was tolerated. For example, if a horse neighed only once during three consecutive days, but never defecated, trotted or galloped, we considered it habituated. The number of days required for habituation was between 3 and 6 days.

2.2.2. Test situations

Animals were subjected to four test situations. Animals born in 2001 (AA01 and W01) were tested at 8 months, 1.5 and 2.5 years of age, while those born in 2002 (AA02 and W02) were only tested at the ages of 8 months and 1.5 years (Table 1).

These tests consisted of potentially fear-eliciting situations, involving either a novel or a sudden stimulus. Suddenness and novelty are considered to be the most stressful stimuli (see Forkman et al., 2007). Moreover, horses are frequently confronted with them when used for riding. All the tests took place in the test pens described above. The tests will be presented in the same order they were carried out. Habituation to the test pen began on day 1, followed by the novel object test, the novel area test, the surprise test-horse free in the pen, and the surprise test-horse held, were carried out on days 12, 39, 40 and 41–45, respectively.

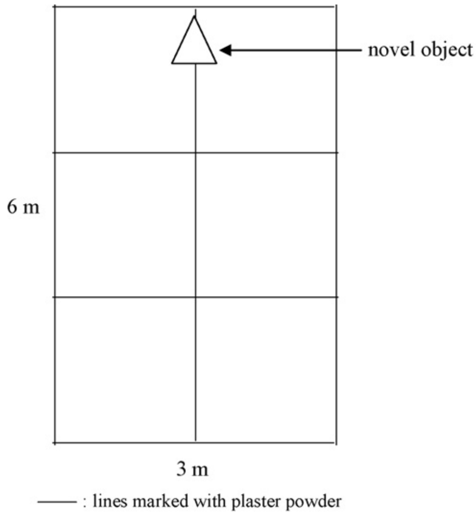

Fig. 3. Test-layout of the novel object test.

2.2.2.1. Novel stimuli

2.2.2.1.1. Novel object test. An object, unknown to the horses, was placed across the width of the pen before the animal entered it (Fig. 3). A different novel object was used for each step of the study. At 8 months, 1.5 years and 2.5 years of age, they were respectively: three green plastic bags (1 m tall) filled with straw, six white plastic bags (0.20 m long) suspended from a black plastic wire normally used for electric fences (0.60 m in diameter, 0.80 m above the ground), and 10 plastic folders of different colors (blue, green, red, purple) suspended by string from the same wire. To evaluate the area covered by the horse, the pen was divided in six sectors of equal size traced with plaster powder (Fig. 3). Horses were habituated to these lines during the habituation period, and they did not show any particular reaction to them during the test. The location of the horse was noted continuously enabling us to measure the ''number of sectors entered'' by the animal, which was an indicator of locomotion during the test. The test lasted 5 min, during which 17 other behavioural parameters were recorded (Table 2).

2.2.2.1.2. Novel area test. Three zones were marked on the floor of the test pen using plaster powder (Fig. 4). The first zone (1.50 m $\times$ 3 m) corresponded to a ''starting zone'', the second to a ''central zone'' (3 m $\times$ 3 m), while the third (1.50 m $\times$ 3 m) corresponded to an ''arrival zone'' and contained a bucket full of food (commercial pelleted food, part of the horses' usual diet).

Habituation. This phase aimed at habituating the test animal to going to the arrival zone containing the food. An experimenter entered the pen with the test animal, led it (without being haltered) to the starting zone and then released it. The handler then immediately entered an adjacent box, out of the horse's sight. The time recording started when the horse's two forelegs crossed the line delimiting the starting zone. The animal had 40 s to cross the line into the arrival zone containing the food and to eat. If it did not succeed, the experimenter led it again to the starting zone (the horse was not fed its normal ration in this case). It was offered eight trials per day. The criterion for this habituation was that the horse performed seven correct trials per day on three consecutive days.

Test. The test was carried out on the day after the horse reached the criterion level. A novel area (3 m $\times$ 2 m) was placed in the middle of the central zone (Fig. 4), differing at each test stage. At 8 months, 1.5 and 2.5 years of age, it consisted respectively of: a white sheet of jute canvas, a plastic cover, and a wooden plank. The procedure was the same as the one used previously: the animal was led to the starting zone, released, and the time recording started when its two forelegs crossed the starting line. However, in this phase, the animal had 5 min to cross the arrival line and to eat, with only one trial. The test ended when the horse ate from the bucket, or after 5 min if it did not eat. Nineteen behavioural parameters were measured during this phase (Table 2).

Table 2
Parameters and definitions of behaviour recorded during the tests

Parameters and definitions when necessary	Novel object	Novel area	Surprise test, foal free
Glances at the stimulus (l, f) the horse stands still, with elevated neck, head and ears oriented in direction of the stimulus	X	X	X
Sniffing the stimulus (l, f)	X	X	X[a]
Licking/nibbling the stimulus (l, f)	X	X	X[a]
Contact with the stimulus (d)	X		
Time to put one foot on the novel area		X	
Time spent near the stimulus		X	
Time to eat		X	X
Flight distance			X
Startle responses (f)	X[a]	X[a]	
Neighing (l, f)	X[a]	X[a]	X[a]
Defecation (l, f)	X[a]	X[a]	X[a]
Trotting (f)	X[a]	X[a]	X[a]
Scrapping the floor with the foot (f)	X[a]	X[a]	X[a]
Vigilant position (f) the horse stands still, with elevated neck, head and ears oriented anywhere except in direction of the stimulus	X	X	X
Sniffing the floor (f)	X	X	X
Blowing (f) forceful expulsion of air through the nostrils preceded by a raspy inhalation sound	X	X	X
Sectors entered (n)	X		

l: latency, f: frequency, d: duration, n: number. 'X' indicates if the parameter was measured during the test or not.
[a] Parameters expressed by less than 15% of animals.

2.2.2.2. Sudden stimuli

The sudden stimuli consisted of the opening of a familiar black umbrella. Identical umbrellas were placed in front of each box for 1 month before the tests in order to familiarize the animals with them.

2.2.2.2.1. Surprise test, horse free in the pen. Before the animal entered the pen, the same bucket of food which was used in the ''novel area'' test was placed in the box, 1 m from the hurdles (Fig. 5). A closed umbrella was placed between two bars of the hurdle, 1 m above the bucket. The animal was released in the pen and when it had eaten for three consecutive seconds from the bucket, the umbrella was automatically opened and the time started. The test ended when the horse went back to the bucket and ate again for three consecutives seconds. The maximum time allowed was 5 min; after that time, the test ended. Seventeen

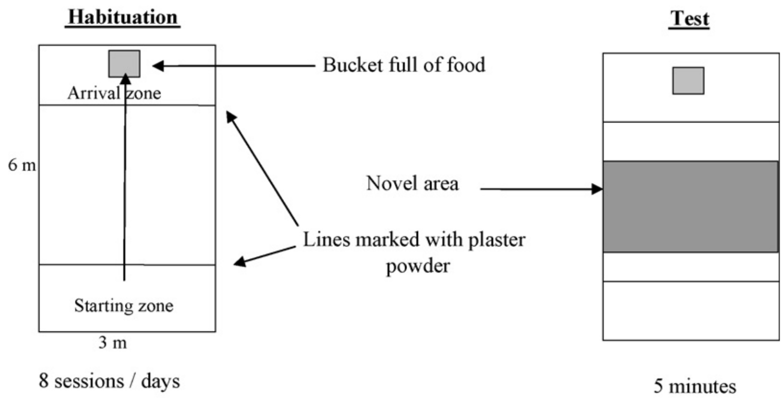

Fig. 4. Test-layout of the novel area test.

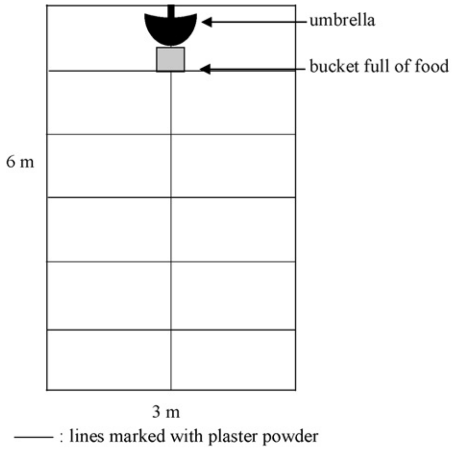

Fig. 5. Test-layout of the surprise test.

behavioural parameters were noted during the test (Table 2). The test was filmed, and the flight distance was measured on the video using lines marked every meter on the floor of the test pen (Fig. 5).

2.2.2.2.2. Surprise test, horse held, and heart rate measurement. During this test, the horse was held to limit the influence of locomotor activity on the heart rate.

When the animal was brought into the pen, the handler tried to fit it with a halter and fit it with a heart rate monitoring system maintained with a surcingle (Polar Accurex Plus) set to record heart rate every 5 s. The experimenter led the horse to the middle of the pen and tried to hold it still throughout the test. An assistant holding a closed umbrella behind his back stood 1.5 m from the horse. The recording began, and 5 min later, the assistant suddenly opened the umbrella twice, 1 m in front of the horse's head, then closed it and hid it again. The total duration of this test was 8 min. This test could not be performed on all the animals because of the difficulty of fitting certain animals with the equipment due to their violent defensive reactions. Therefore, the experimenter was given a maximum of 30 min to catch the horse and fit the equipment. If he did not succeed in this time, because the horse's reactions were too dangerous, the test was abandoned. The number of horses subjected to the entire test is presented in Table 1.

As animals presented various reactions when they were fitted with the equipment (some stayed relatively calm whereas others had strong defensive reactions), there was a wide variation in their heart rates measured before the surprise effect. To limit this effect, we analysed the change in heart rate before and after the opening of the umbrella. To do so, we measured the minimum and maximum heart rate and calculated the average during the 5 min before the opening of the umbrella. After that, several indexes were calculated: the difference between the maximum heart rate and the average, the difference between the maximum and the minimum, the percentage of the maximum as a function of the minimum or the average.

2.3. Statistical analyses

The statistical analyses used in this study are strictly identical to those used by Lansade et al. (2008) and Lansade and Bouissou (in press). The same protocol was repeated twice in two groups (AA02 and W02) and three times in the others (AA01 and W01). We did not combine the data from these different time points and groups (for justification, see Lansade et al., 2008; Lansade and Bouissou, in press).

Some behavioural parameters were expressed by less than 15% of animals and were not taken into account in the statistical analysis; they are presented in Table 2. Two different analyses were performed:

the first concerned the links between parameters measured at different ages (stability over time) and the second was aimed at quantifying the relationship between parameters of the different tests at the same point in time (stability across situations: inter-test correlations). To study the relationship between parameters, Spearman (rank) correlations were calculated, since they are more robust to data non-normality than the Pearson correlations. A correlation was considered to be statistically significant when its p-value was less than 0.05.

The relationship between variables (stability across situations) was calculated for 10 separate sets of data (Groups AA01 and W01 were tested three times, and groups AA02 and W02 were tested twice, resulting in 10 sets). The number of significant positive or negative correlations out of 10 is presented in matrix form showing only the variables which are correlated with one or more variable from the other tests. On the other hand, investigating stability over time involves fewer possible correlations, and the significant correlations ($p < 0.05$) are therefore presented in a table with the Spearman correlation coefficient (R-value). To investigate stability over time, eight correlation possibilities were calculated (8 months vs. 1.5 years for all four groups, 8 months vs. 2.5 years and 1.5 years vs. 2.5 years for groups W01 and AA01). No parameter was established to accept or reject the hypothesis of stability, on the assumption that stability can be measured on a gradient, with some variables never correlated over time or with each other, and some which are correlated in 100% of cases.

3. Results

3.1. Stability over time: search for correlations between parameters measured at different ages

The R-values of these correlations are presented in Table 3.

3.1.1. Novel object test

The parameters which were the most often correlated over time are the frequencies of licking/nibbling (in 8 units out of 8), the duration of contact and the frequency of glances (in 7 units out of 8), the latency of licking/nibbling and the frequency and latency of sniffing (in 6 units out of 8), and the frequency of blowing (in 4 units out of 8). Three other parameters were sometimes correlated between ages, but less frequently (Table 3).

3.1.2. Novel area test

The parameters which were the most often correlated over time were the time to put one foot on the novel area and the time to eat (in 8 units out of 8), followed by the frequency of glances (in 7 units), the frequency of sniffing the floor (in 6 units), the frequency of vigilant position (in 5 units). Five other parameters present few correlations over time and are presented in Table 3.

3.1.3. Surprise test, horse free

The parameters which were the most often correlated over time were the flight distance and the time to eat (in 7 units out of 8), followed by the frequency of glances (in 6 units). The other three parameters presented in the table were correlated less frequently.

3.1.4. Surprise test, horse held

The parameters which were the most often correlated over time were the ‘‘maximum heart rate’’, the ‘‘maximum–average heart rate’’ and the ‘‘maximum–minimum heart rate’’, but only in 4 units out of 8. The other two parameters were only correlated in 3 units.

Table 3
Stability over time, search for correlations between parameters measured at different ages

	Number of significant correlations out of 8	W01			W02 (8 months to 1.5 years)	AA01			AA02 (8 months to 1.5 years)
		8 months to 1.5 years	1.5 years to 2.5 years	8 months to 2.5 years		8 months to 1.5 years	1.5 years to 2.5 years	8 months to 2.5 years	
Novel object test									
Licking/nibbling (f)	8	0.76	0.59	0.60	0.51	0.47	0.60	0.58	0.41
Contact (d)	7	0.75	0.60	0.71	0.51	0.40	0.59	0.41	
Glances (f)	7	0.56	0.56	0.61	0.38	0.46	0.70	0.61	
Licking/nibbling (l)	6	0.61	0.67	0.48		0.43	0.45	0.41	
Sniffing (l)	6	0.65	0.58	0.61	0.49	0.51	0.67		
Sniffing (f)	6	0.68	0.61	0.66		0.53	0.61	0.44	
Blowing (f)	4	0.54	0.58	0.44	0.35				
Sectors entered (n)	2			0.37				0.44	
Glances (l)	1							0.46	
Vigilant position (f)	1				0.36				
Novel area test									
Time to put one foot	8	0.71	0.69	0.75	0.50	0.61	0.66	0.64	0.57
Time to eat	8	0.79	0.60	0.67	0.55	0.55	0.46	0.51	0.65
Glances (f)	7	0.54	0.66	0.69		0.53	0.65	0.59	0.52
Sniffing the floor (f)	6	0.69	0.80	0.67	0.58	0.55			0.60
Vigilant position (f)	5	0.70	0.66	0.55	0.54	0.53			
Licking/nibbling (f)	3		0.38			0.48			0.56
Sniffing (l)	3		0.68	0.66					0.42
Sniffing (f)	2		0.51		0.38				
Time near the area	2		0.71	0.35					
Licking/nibbling (l)	1								0.52
Surprise test, horse free									
Flight distance	7	0.35	0.61		0.56	0.62	0.79	0.58	0.37
Time to eat	7	0.36	0.69		0.48	0.74	0.65	0.62	0.52
Glances (f)	6		0.61		0.58	0.58	0.68	0.62	0.50
Sniffing the floor (f)	3		0.57		0.37		0.50		

Table 3 (*Continued*)

	Number of significant correlations out of 8	W01			W02 (8 months to 1.5 years)	AA01			AA02 (8 months to 1.5 years)
		8 months to 1.5 years	1.5 years to 2.5 years	8 months to 2.5 years		8 months to 1.5 years	1.5 years to 2.5 years	8 months to 2.5 years	
Vigilant position (f)	2			0.36	0.41				
Blowing (f)	2				0.67				0.49
Surprise test, horse tethered									
Maximum HR	4	0.41		0.45		0.53	0.80		
Maximum HR–average HR	4	0.40		0.60		0.44	0.62		
Maximum HR–minimum HR	4	0.40		0.49		0.44	0.70		
Maximum HR × 100/minimum HR	3	0.44		0.56			0.50		
Maximum HR × 100/average HR	3	0.47		0.49	0.46				

This table presents the parameters which are correlated at less one time between two different ages. For each test, they are classified from the more frequently correlated to the less frequently correlated. The numbers presented in the table correspond to the spearman correlation coefficient (R-value). This number is presented only when the correlation was significant ($p < 0.05$). l: latency, f: frequency, d: duration, n: number, HR = heart rate.

3.2. Stability across situations: search for correlations between parameters measured during different tests (inter-test correlations)

3.2.1. Novel object test and novel area test

The more rapidly and frequently the horses licked/nibbled and sniffed the object, the more rapidly they put one foot on the area and ate, and to a certain extent the less they glanced at the area. The number of units in which these correlations appear are presented in Table 4 (see also Fig. 6 for illustrations of some of these correlations). Other parameters were correlated between these two tests, but less frequently.

Table 4
Stability across situations, search for correlations between parameters measured during the novel object test and the novel area test

			Novel object test				
number of significant correlations between ages ↓		→	8/8	6/8	6/8	6/8	4/8
			Frequency of licking / nibbling the object	Latency of licking / nibbling the object	Latency of sniffing the object	Frequency of sniffing the object	Frequency of blowing
Novel area test	8/8	Time to put one foot on the area	6 (-)*	7 (+)	7 (+)	5 (-)	
	8/8	Time to eat	5 (-)	5 (+)	5 (+)	3 (-)	
	7/8	Frequency of glances at the area	5 (-)	5 (+)	5 (+)	2 (-)	
	6/8	Frequency of sniffing the floor	2 (-)				6 (+)
	5/8	Frequency of vigilant positions	4 (-)	5 (+)	6 (+)		3 (+)
	3/8	Latency of sniffing the area	5 (-)	2 (+)	5 (+)	3 (-)	
	0/8	Frequency of blowing					7 (+)

The numbers indicated in the table correspond to the number of significant correlations out of the 10 possibilities of correlations calculated between two parameters. When this number is equal to 0, the box is empty. The direction of the relationship is also indicated (+: positive correlation; −: negative correlation). Only the parameters which are correlated with one or more parameter of the other test are presented. The parameters are presented from the more stable over time to the less stable. Note the shades of grey: the darker the box, the more stable the parameter over time and the more frequently it is correlated with parameters of the other test.
*As an example of the results, some graphs are presented in Fig. 6 to illustrate some of these correlations.

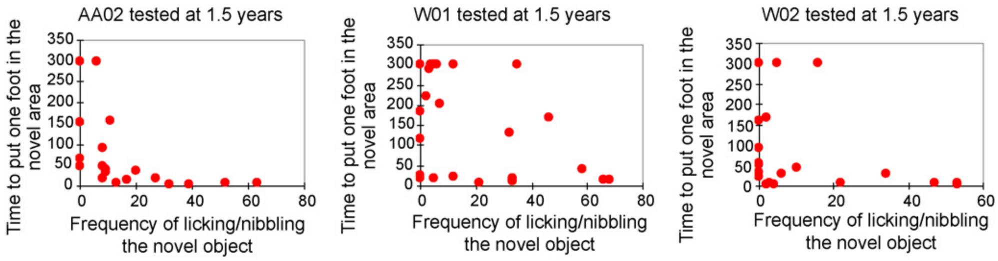

Fig. 6. Example of graphs presenting the relationships between parameters: relationships between the time to put one foot in the novel area and the frequency of licking/nibbling the novel object in group AA02, W01 and W02 tested at 1.5 years of age. The relationships were tested with Spearman's correlations with the following results: $R = -0.79$, $p < 0.0001$; $R = -0.51$, $p < 0.001$; $R = -0.58$, $p < 0.0001$, respectively. Of the four groups tested at 1.5 years of age, only group AA01 did not present significant correlation between these two parameters.

3.2.2. Novel object test and surprise test, horse free

The more rapidly and frequently the horses licked/nibbled and sniffed the object and the longer they spent in contact with it, the shorter the flight distance, and the faster they returned to eat after the surprise effect. Moreover, the more rapidly they licked/nibbled and sniffed the

Table 5
Stability across situations, search for correlations between parameters measured during the novel object test and the surprise test, horse free

			Novel object test					
	number of significant correlations between ages →		8 / 8	7 / 8	6 / 8	6 / 8	6 / 8	4 / 8
	↓		Frequency of licking/ nibbling the object	Duration of contact with the object	Latency of sniffing the object	Frequency of sniffing the object	Latency of licking/ nibbling the object	Frequency of blowing
Surprise test, horse free	7 / 8	Flight distance	7 (-)	5 (-)	6 (+)	5 (-)	7 (+)	2 (+)
	7 / 8	Time to eat	7 (-)	5 (-)	5 (+)	4 (-)	6 (+)	
	6 / 8	Frequency of glances at the umbrella	4 (-)	4 (-)	5 (+)	3 (-)	5 (+)	
	3 / 8	Frequency of sniffing the floor	1 (-)		5 (+)	3 (-)		4 (+)
	2 / 8	Frequency of blowing						6 (+)

The numbers indicated in the table correspond to the number of significant correlations out of the 10 possibilities of correlations calculated between two parameters. When this number is equal to 0, the box is empty. The direction of the relationship is also indicated (+: positive correlation; −: negative correlation). Only the parameters which are correlated with one or more parameter of the other test are presented. The parameters are presented from the more stable over time to the less stable. Note the shades of grey: the darker the box, the more stable the parameter over time and the more frequently it is correlated with parameters of the other test.

object, the less they glanced at the umbrella. These correlations appear generally in 5–7 units out of 10 (Table 5). Other parameters were correlated between these two tests, but less frequently.

3.2.3. Novel area and surprise test, horse free

The faster the horses put one foot on the area and ate in the novel area test, the shorter the flight distance and the faster they returned to eat during the surprise test. Moreover, the more they glanced during the novel area test, the shorter the flight distance, the faster they returned to eat and the more frequently they glanced at the umbrella and sniffed the floor during the surprise test. These correlations appear in 5–8 units out of 10 (Table 6).

It can be seen from the last three paragraphs that the parameters which are the most often correlated between the different tests are generally those which show the best stability over time (see Tables 4–6).

3.2.4. Surprise test, horse held and the other three tests

No parameters of the surprise test with the horse held were correlated with parameters of the novel area and the novel object test. There was only one correlation between the surprise test with the horse held and the surprise test with the horse free, namely, the ‘‘maximum–minimum heart rate’’ and flight distance. This correlation was significant in 5 units out of 10.

Table 6
Stability across situations, search for correlations between parameters measured during the novel area test and the surprise test, horse free

			Novel area test			
	number of significant correlations between ages → ↓		8 / 8	8 / 8	7 / 8	0 / 8
			Time to put one foot on the area	Time to eat	Frequency of glances at the area	Frequency of blowing
Surprise test, horse free	7 / 8	Flight distance	6 (+)	6 (+)	8 (+)	
	7 / 8	Time to eat	6 (+)	6 (+)	5 (+)	
	6 / 8	Frequency of glances at the umbrella	4 (+)	4(+)	5 (+)	
	3 / 8	Frequency of sniffing the floor			5 (+)	1 (+)
	2 / 8	Frequency of vigilant positions				5 (+)

The numbers indicated in the table correspond to the number of significant correlations out of the 10 possibilities of correlations calculated between two parameters. When this number is equal to 0, the box is empty. The direction of the relationship is also indicated (+: positive correlation; −: negative correlation). Only the parameters which are correlated with one or more parameter of the other test are presented. The parameters are presented from the more stable over time to the less stable. Note the shades of grey: the darker the box, the more stable the parameter over time and the more frequently it is correlated with parameters of the other test.

4. Discussion

The purpose of this paper was to examine whether a possible trait of fearfulness can be inferred from some of the behaviours expressed by horses during potentially fear-eliciting test situations.

Among the many behavioural parameters observed during the tests, we explored which ones presented stability over time and across situations. Sniffing or licking/nibbling the novel object, the times to put one foot on the novel area and to eat in the novel area test, the flight distance and the time to return to eat under the umbrella in the surprise test, as well as the glances at the stimulus in the novel area and the surprise tests presented such stability. The stability across situations of these parameters means that an animal which does not sniff, lick or nibble the novel object will look frequently at the novel area, will not put one foot on it or will not eat. It also has a long flight distance and eats after a long time during the surprise test. The stability over time means that an animal which shows these reactions at 8 months of age will also show them at 1.5 and 2.5 years of age.

These two aspects of stability mean that these behavioural parameters can be considered as the reflection of a trait of temperament. According to Gray (1987), Boissy (1998) and de Catanzaro (1999), the situations of novelty and suddenness used in this study are potentially fear inducing. Consequently, this trait can be called fearfulness. In addition, among the different parameters cited above, some of them showed better stability over time than others. These parameters were the frequency of licking/nibbling in the novel object test, the time to put one foot on the area and to eat in the novel area test, and the flight distance and the time to eat in the surprise test. The first three parameters were significantly correlated over time in all the units, and the last two parameters in 7 units out of 8. They can be considered as the best behavioural indicators of a trait of fearfulness in this study.

Concerning stability across situations, our results are in line with many studies which show links between reactions to different fear-inducing situations (rat: Broadhurst, 1957; Van der Staay et al., 1990; chicken: Jones, 1987, 1988; Jones and Mills, 1983; Japanese quail: Mills and Faure, 1986; dog: Goddard and Beilharz, 1984; cattle: Boissy and Bouissou, 1991; goat: Lyons et al., 1988; sheep: Romeyer and Bouissou, 1992; Vandenheede et al., 1998; Viérin and Bouissou, 2003 or horse: Viérin et al., 1998). However, in many of these studies, the correlations found between the different situations may be due to the existence of common elements in all of the tests situations, such as isolation or novel environment. This is theoretically not the case in the present study. However, while we checked that the audience animals did not express any particular behaviour related to the fearful stimuli, we cannot be sure that they did not influence the reactions of some test animals. Thus, we cannot exclude the possibility that this potential social effect may be considered as a ‘‘common element’’.

Concerning the stability over time, this is the first time that such long-term stability (from 8 months to 2.5 years of age) has been demonstrated in horses. Previously, Seaman et al. (2002) attempted to determine a consistency of responses to a novel object over a period of 18 days, but without success. Visser et al. (2001) also examined the stability of behaviours, but over a 1-year period. They found that only a few parameters were stable and they concluded that long-term stability could not be demonstrated convincingly. The low number of stable parameters over time found in the Visser et al. (2001) study may be explained by the fact that their tests involved several aspects of temperament, such as reaction to isolation, to humans or to restraint, in addition to the reactions to novel stimuli.

At this stage, we should point out that we deliberately only used experimental situations with a well-identified fear-eliciting event, and the responses were thus highly specific to the characteristics of the test conditions. Consequently, our results are likely to be different in conditions with less well-identified fear-eliciting events, for example, when novelty concerns the environment as a whole, or when suddenness involves a sound.

The other parameters measured during the tests, such as neighing, defecation, sniffing the floor, blowing or vigilant positions were either too rarely expressed to be analysed or were not sufficiently stable across time and situations. Thus, they cannot be considered as good indicators of a fearfulness trait in this study. Some authors, such as Viérin et al. (1998) in horses or Romeyer and Bouissou (1992) in sheep, interpreted these behaviours in terms of presence of fear. It is interesting to notice that unlike the above behaviours, these are less specific to the stimulus. Thus, it is possible that they could have been more involved as fear indicators in a novel arena design with no specifically located event than in our tests. Moreover, these behaviours can be expressed when the animal is frightened, but they are not sufficiently stable to be a specific reflection of a trait of temperament.

In addition to the study of behavioural parameters, we also investigated if heart rate can be used as an indicator of a trait of fearfulness. The different measures and indexes of the heart rate observed or calculated during the surprise test, when the horses were held, show poor stability over time and were never correlated with parameters of the novel object test or the novel area test. Only one of them was correlated with one parameter of the surprise test, when the horse was free (the ‘‘heart rate maximum–heart rate minimum’’ was correlated with the flight distance). Thus, due to the low stability of the different measures of heart rate, this test does not provide a valid measure of fearfulness under our conditions, particularly with young horses not used to being handled. An absence of links between behavioural and physiological responses such as defecation, corticoids and cardiac frequency has already been reported elsewhere (sheep: Torres-Hernandez and Hohenboken, 1979; cattle: de Passillé et al., 1995; goat: Lyons and Price, 1987; rat: Young and Leaton, 1994). Concerning stability over time, Visser et al. (2002) found that heart rate parameters measured during a fear-eliciting test (novel object test) was correlated between 9 and 21 months of age. In our study, these correlations over time were also found, but only in 4 units out of the 8 tested. This difference can probably be explained by the difference between our protocols: in Visser et al.'s study, horses were free during the recording whereas in our study they were held to avoid locomotor activity influencing the heart rate. Thus, the reaction to the presence of a human and to restraint may have strongly influenced their heart rate, particularly for the horses which were difficult to fit with the equipment due to their strong defensive reactions. Moreover, in contrast to the other three tests, the horses could not avoid the frightening stimuli. It is well known that the degree of control an animal can exert over its threatening environment by appropriate behaviour determines the perception the animal has of it and its reaction (Boissy, 1998). This was demonstrated by Weiss (1972) in rats which received an electric shock, with or without the possibility of stopping it. How well an individual can control the event, and possibly the extent to which it can act on the situation is moreover known to be one evaluation criteria involved in the development of emotional reactions (for a review: Désiré et al., 2002). Finally, the measure of heart rate we carried out may not be reliable: it is a very sensitive measure, which can be strongly influenced by many uncontrollable events such as the internal state (emotional or physiological) of the individual at the moment of the test, its locomotor activity or movements of its body or different external stimulations (e.g. sound in the stable) which can cause an increase in heart rate. In contrast to cardiac frequency, it is highly probable that other cardiac measures such as heart rate variability, used successfully by Visser et al. (2002), would be a better indicator of certain aspects of temperament if they are measured during appropriate conditions (for a review: von Borell et al., 2007).

Finally, this study also allowed us to examine if the stability of behaviour is a function of age. Many studies have found that the stability of behaviours increases with age. For example, in dogs, adult fearfulness could be predicted to some degree from fear reactions observed at 3 months of age, but the accuracy of the prediction improved with age (Goddard and Beilharz, 1984). In the present study, stability does not seem to change between 8 months and 2.5 years of age: there are not more significant correlations between 1.5 and 2.5 years than between 8 months and 1.5 years, and the values of R do not seem to increase with age. Lansade et al. (2007), studying the same horses as those used in the present experiment but from birth to 6 months of age (corresponding to the age of artificial weaning), found an age-dependent increase in stability during this period. Young foals expressed very few behaviours towards fear stimuli, neither approach reactions towards a novel object, nor avoidance reaction to a surprise effect. These reactions appeared progressively with age from birth to 6 months of age, but once these reactions appeared, they were stable over time. The present study complements this result by showing that behavioural stability may have reached a peak by about 6–8 months of age.

5. Conclusion

To conclude, this study shows that the level of fearfulness of an individual can be determined by observation of a few specific behaviours during short tests performed as early as 8 months of age. It is thus possible to select animals according to fearfulness from this age. The next goal will be to determine which level of fearfulness is appropriate for selection, depending on the specific use of the horse.

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ORIGINAL ARTICLE

Non-fatal horse related injuries treated in emergency departments in the United States, 2001–2003

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Objective: To characterise and provide nationally representative estimates of persons with non-fatal horse related injuries treated in American emergency departments.
Methods: The National Electronic Injury Surveillance System All Injury Program (NEISS–AIP) is a stratified probability sample comprising 66 hospitals. Data on injuries treated in these emergency departments are collected and reported. NEISS–AIP data on all types (horseback riding and otherwise) of non-fatal horse related injuries from 2001 to 2003 were analysed.
Results: An estimated 102 904 persons with non-fatal horse related injuries (35.7 per 100 000 population) were treated in American emergency departments each year from 2001 to 2003 inclusive. Non-fatal injury rates were higher for females (41.5 per 100 000) than for males (29.8 per 100 000). Most patients were injured while mounted on a horse (66.1%), commonly from falling or being thrown by the horse; while not mounted, injuries most often resulted from being kicked by the horse. The body parts most often injured were the head/neck region (23.2%), lower extremity (22.2%), and upper extremity (21.5%). The most common principal diagnoses were contusions/abrasions (31.4%) and fractures (25.2%). For each year that was studied, an estimated 11 502 people sustained traumatic brain injuries from horse related incidents. Overall, more than 11% of those injured were admitted to hospital.
Conclusions: Horse related injuries are a public health concern not just for riders but for anyone in close contact with horses. Prevention programmes should target horseback riders and horse caregivers to promote helmet use and educate participants about horse behaviour, proper handling of horses, and safe riding practices.

Horseback riding is a popular recreational activity in the USA, particularly within certain demographic groups and regions of the country. In the USA, there are an estimated 9.2 million horses,[1] with more than 19 million people aged 16 years and older participating in riding activities.[2] Along with participation comes the risk of injury. A survey conducted of randomly selected households receiving a national horseback riding equipment catalogue found that 27.5% of participants aged 25 years and younger who rode six or more times a year had been treated by a physician in the past two years for a horse related injury, and 6.1% had been admitted to hospital for a horse related injury in their lifetime.[3] Even though horse related activities have fewer participants than other sports and recreation activities, horseback riding is the eighth leading cause of emergency department treated, sports and recreation related injuries among female participants.[4]

Horseback riding and related activities have unique characteristics, with implications for the injuries sustained. Horse related sports are among the few sports in which participants from two different species function as a team, with the horse having the ability to act independently and unpredictably.[5] In addition, horses are large and fast—often weighing 450 kg (1000 pounds) or more and travelling up to 48 km/h (30 mph)—with the rider's head up to 3 m (over 9 ft) above the ground.[5 6] Even when not mounted on a horse, a person can be seriously injured—a horse's kick can generate a force up to 1.8 times its body weight.[7]

Although many studies describe injuries sustained in horse related incidents, most describe patients treated in a single medical centre.[7–15] Most national studies conducted in the USA have focused on paediatric populations.[16 17] This study provides current and comprehensive national estimates of all types (horseback riding and otherwise) of non-fatal horse related injuries treated in American hospital emergency departments, and characterises these injury incidents by demographics of the person injured, injury circumstances, types of injury, and disposition at discharge from the emergency department. In addition, previous injury prevention recommendations are discussed and placed in context using the surveillance data.

METHODS

The National Electronic Injury Surveillance System (NEISS) is an emergency department surveillance system operated by the US Consumer Product Safety Commission.[18] The system was designed to generate national estimates of consumer product related injuries. NEISS is a nationally representative stratified sample of 99 hospitals in the USA and its territories that have at least six beds and provide 24 hour emergency care. The hospitals are stratified into four categories based on the annual number of emergency department visits, with a fifth stratum for children's hospitals.

The NEISS All Injury Program (NEISS–AIP) is a subsample of 66 of the 99 NEISS hospitals.[19] In these emergency departments, data are collected on all injuries, regardless of cause or consumer product involvement. NEISS–AIP collects data on approximately 500 000 injury related emergency department visits annually, including age, sex, day and month of treatment, consumer products involved, primary body part injured, principal diagnosis, disposition at emergency department discharge, and a two line narrative describing the injuries and circumstances. Because the

Abbreviations: ATV, all-terrain vehicle; NEISS–AIP, National Electronic Injury Surveillance System All Injury Program; SR, sports and recreation analysis of NEISS–AIP data does not involve patient contact, these data are exempt from institutional review board approval.

Cases were defined as patients injured while engaged in horse related activities (riding, mounting or dismounting, caring for a horse while not mounted, riding in a horse drawn buggy/cart, or being run over by a horse drawn vehicle). Cases were identified if one of two criteria was met: (1) if one of the two consumer product codes was ''horseback riding—activity, apparel, or equipment''; or (2) if one of the product codes was ''animal induced injury'' and the narrative included the word ''horse'' or ''pony.'' Because NEISS–AIP does not capture all deaths, patients who were dead on arrival or who died while in the emergency department were excluded. Other types of cases were also excluded: motor vehicle occupants injured in a collision with a horse; injuries involving horse related equipment without mention of a horse (for example, tripped over a saddle on the floor); injuries associated with donkeys or mules; persons injured while in the barn or pasture with no mention of direct horse involvement (for example, falling while in the barn to feed horses); and persons who sought emergency department care because of a second unrelated injury incident (for example, motor vehicle crash today, fell off horse last week). In addition to the routinely collected NEISS–AIP variables, one author reviewed the narratives and coded additional circumstance variables. These included the mechanism of injury (fall, crush); whether the person was mounted, not mounted, or in the process of mounting/dismounting; other circumstances (horse tripped, person fell, and so on); and specific diagnoses (such as traumatic brain injury).

Each case was assigned a sample weight based on the inverse probability of selection and both non-response and post-stratification adjustments to account for changes in the total number of American hospital emergency department visits over time. These weights were summed to produce national estimates. The national estimates were based on weighted data for 4122 cases of horse related injuries seen in NEISS–AIP hospitals from 2001 to 2003 inclusive. Estimates were annualised by dividing the weighted totals by 3. Rates were calculated using the US Census 2001–2003 bridged race population estimates obtained from the National Center for Health Statistics.[20] Confidence intervals were calculated using a direct variance estimation procedure that accounted for the sample weights and complex sampling design.

RESULTS

Each year from 2001 to 2003, an estimated 102 904 people (35.7 per 100 000 population) were treated in American hospital emergency departments for horse related injuries. About 19% of those were 14 years of age or younger (table 1). Overall, females had higher rates of injury than males, but sex specific rates and the differences between female and

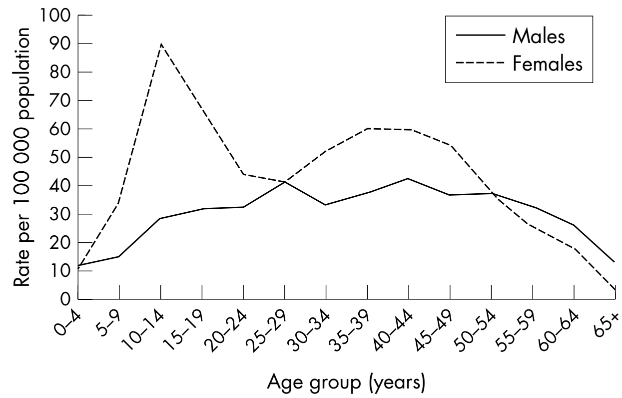

Figure 1 National annual rates of non-fatal horse related injuries treated in emergency departments, by sex and age group—USA, 2001–2003.

Table 1 National estimates* and rates† of non-fatal horse related injuries treated in emergency departments, by age group, sex, and disposition at emergency department discharge—USA, 2001–2003

Characteristic	Annual estimate	Percentage	Rate	(95% CI)
Age (years)				
0–4	2188	2.1	11.2	(7.1 to 15.3)
5–9	4936	4.8	24.7	(17.4 to 32.0)
10–14	12 392	12.0	58.9	(43.4 to 74.3)
15–19	10 053	9.8	49.4	(35.3 to 63.4)
20–24	7795	7.6	38.4	(28.2 to 48.7)
25–29	7854	7.6	41.3	(31.3 to 51.4)
30–34	8843	8.6	42.6	(30.4 to 54.8)
35–39	10 640	10.3	48.8	(35.3 to 62.2)
40–44	11 807	11.5	51.6	(37.5 to 65.7)
45–49	9763	9.5	45.9	(31.8 to 60.0)
50–54	7004	6.8	37.4	(27.7 to 47.1)
55–59	4377	4.3	29.2	(18.4 to 40.0)
60–64	2555	2.5	22.0	(12.1 to 31.9)
65+	2665	2.6	7.5	(4.7 to 10.2)
Unknown	33	0.0	–	–
Sex				
Male	42 162	41.0	29.8	(22.1 to 37.5)
Female	60 703	59.0	41.5	(30.2 to 52.7)
Unknown	39	0.0	–	–
Disposition at ED discharge				
Treated and released	90 776	88.2	31.5	(24.1 to 39.0)
Admitted to hospital/transferred	11 481	11.2	4.0	(2.3 to 5.7)
Other/unknown	646	0.6	–	–
Total	102 904	100.0	35.7	(26.9 to 44.6)

*Numbers may not add up to totals because of rounding.
†Per 100 000 population.
CI, confidence interval; ED, emergency department.

Table 2 National estimates* of non-fatal horse related injuries treated in emergency departments, by selected injury characteristics, overall, and for those mounted or not mounted at time of injury—USA, 2001–2003

	Total†			Mounted			Not mounted		
Characteristic	**Annual estimate**	**(95% CI)**	**%**	**Annual estimate**	**(95% CI)**	**%**	**Annual estimate**	**(95% CI)**	**%**
Was the person mounted?									
Mounted	68 027	(50 253 to 85 800)	66.1	68 027	(50 253 to 85 800)	100.0	–	–	–
Not mounted	30 288	(23 224 to 37 353)	29.4	–	–	–	30 288	(23 224 to 37 353)	100.0
Mounting	1061	(627 to 1495)	1.0	–	–	–	–	–	–
Dismounting	1438	(837 to 2039)	1.4	–	–	–	–	–	–
Other/unknown	2090	(993 to 3187)	2.0	–	–	–	–	–	–
Mechanism of injury									
Fall	56 654	(42 081 to 71 227)	55.1	53 691	(40 103 to 67 280)	78.9	1200	(678 to 1723)	4.0
Struck by or against	24 721	(18 815 to 30 626)	24.0	6576	(4182 to 8970)	9.7	17 155	(13 405 to 20 905)	56.6
Crush	13 572	(9498 to 17 646)	13.2	5377	(3566 to 7188)	7.9	7740	(5262 to 10 218)	25.6
Overexertion	5489	(3977 to 7001)	5.3	2169	(1393 to 2945)	3.2	2330	(1551 to 3109)	7.7
Bite	1779	(1087 to 2470)	1.7	–	–	–	1779	(1087 to 2470)	5.9
Other/unknown	689‡	(270 to 1109)	0.7	213‡	(52 to 375)	0.3	84‡	(−50 to 218)	0.3
Was the injury work related?									
Yes	5977	(4126 to 7829)	5.8	2461	(1363 to 3558)	3.6	3278	(2218 to 4338)	10.8
No	95 922	(71 249 to 120 595)	93.2	65 106	(47 597 to 82 616)	95.7	26 506	(20 085 to 32 927)	87.5
Unknown	1004	(450 to 1558)	1.0	459‡	(118 to 800)	0.7	504‡	(203 to 806)	1.7
Primary body part injured									
Head/neck	23 883	(15 739 to 32 026)	23.2	16 789	(10 360 to 23 219)	24.7	6107	(4328 to 7886)	20.2
Head	13 785	(7971 to 19 599)	13.4	10 957	(6127 to 15 787)	16.1	2398	(1427 to 3370)	7.9
Face	5753	(4190 to 7316)	5.6	2554	(1756 to 3353)	3.8	2869	(1985 to 3754)	9.5
Neck	2988	(1978 to 3998)	2.9	2564	(1567 to 3560)	3.8	322‡	(8 to 636)	1.1
Eye, mouth, ear	1356	(864 to 1848)	1.3	715	(358 to 1071)	1.1	517	(240 to 794)	1.7
Upper trunk	18 208	(13 270 to 23 146)	17.7	13 747	(9956 to 17 539)	20.2	3999	(2807 to 5190)	13.2
Shoulder	8073	(6023 to 10 123)	7.8	6445	(4681 to 8209)	9.5	1450	(1003 to 1896)	4.8
Other upper trunk	10 135	(6819 to 13 450)	9.8	7302	(4712 to 9892)	10.7	2549	(1667 to 3431)	8.4
Lower trunk	15 034	(11 403 to 18 664)	14.6	12 921	(9685 to 16 157)	19.0	1832	(1246 to 2418)	6.0
Upper extremities	22 093	(17 112 to 27 073)	21.5	13 127	(10 028 to 16 227)	19.3	7723	(5867 to 9579)	25.5
Upper arm	1737	(1104 to 2370)	1.7	1200	(738 to 1662)	1.8	368‡	(131 to 606)	1.2
Elbow	3112	(2068 to 4156)	3.0	2379	(1645 to 3113)	3.5	531‡	(207 to 854)	1.8
Lower arm	5240	(3864 to 6616)	5.1	3430	(2434 to 4426)	5.0	1426	(907 to 1946)	4.7
Wrist	4119	(2971 to 5267)	4.0	3352	(2385 to 4318)	4.9	635	(375 to 894)	2.1
Hand	2924	(2161 to 3687)	2.8	1026	(600 to 1451)	1.5	1793	(1265 to 2322)	5.9
Finger	4961	(3509 to 6414)	4.8	1741	(1095 to 2387)	2.6	2970	(2108 to 3831)	9.8
Lower extremities	22 801	(17 359 to 28 243)	22.2	10 704	(8148 to 13 260)	15.7	10 517	(7716 to 13 318)	34.7
Upper leg	2346	(1535 to 3157)	2.3	1202	(630 to 1774)	1.8	1070	(640 to 1500)	3.5
Knee	4056	(2999 to 5112)	3.9	2441	(1672 to 3210)	3.6	1270	(809 to 1730)	4.2
Lower leg	4925	(3627 to 6224)	4.8	2364	(1640 to 3089)	3.5	2267	(1572 to 2961)	7.5
Ankle	5359	(3935 to 6783)	5.2	3628	(2716 to 4539)	5.3	983	(499 to 1467)	3.2
Foot	4778	(3214 to 6341)	4.6	950	(588 to 1311)	1.4	3719	(2275 to 5163)	12.3
Toe	1337	(737 to 1937)	1.3	120‡	(−53 to 293)	0.2	1209	(686 to 1731)	4.0
Other/unknown	886	(483 to 1288)	0.9	737	(349 to 1125)	1.1	112‡	(−49 to 272)	0.4

Table 2 Continued

Characteristic	Total† Annual estimate	Total† (95% CI)	Total† %	Mounted Annual estimate	Mounted (95% CI)	Mounted %	Not mounted Annual estimate	Not mounted (95% CI)	Not mounted %
Principal diagnosis									
Contusion/abrasion	32 293	(25 224 to 39 362)	31.4	18 956	(14 592 to 23 320)	27.9	12 357	(9338 to 15 375)	40.8
Fracture	25 905	(18 924 to 32 887)	25.2	19 032	(13 801 to 24 264)	28.0	5712	(3946 to 7477)	18.9
Strain/sprain	16 233	(12 036 to 20 429)	15.8	12 551	(9100 to 16 002)	18.5	2499	(1676 to 3321)	8.3
Concussion/internal injury (head)	9985	(4687 to 15 284)	9.7	8068	(3685 to 12 451)	11.9	1641	(774 to 2508)	5.4
Laceration	7933	(5945 to 9922)	7.7	3536	(2407 to 4665)	5.2	3893	(2892 to 4894)	12.9
Haematoma	1891	(1196 to 2587)	1.8	1095	(570 to 1620)	1.6	686	(386 to 986)	2.3
Dislocation	1864	(1233 to 2494)	1.8	1414	(859 to 1968)	2.1	353‡	(133 to 573)	1.2
Other/unknown	6799	(4348 to 9249)	6.6	3374	(1661 to 5087)	5.0	3148	(2165 to 4131)	10.4

*Numbers may not add up to totals because of rounding.
†"Total" will not equal sum of "Mounted" and "Not mounted" because Total includes the additional categories of "Mounting", "Dismounting", and "Other/unknown".
‡Estimate may be unstable because the coefficient of variation is more than 30%.
CI, confidence interval.

male rates varied across age groups (table 1, fig 1). Injury rates for females peaked at 10–14 years (90.6 per 100 000) and at 35–44 years (60.2 per 100 000). Ages 10–14 years also had the greatest difference in rates by sex, the female rate being more than three times the male rate. For patients aged 55 years and older, males had somewhat higher rates than females. Of all patients treated for horse related injuries, more than 11% were admitted to hospital or transferred for a higher level of care.

Overall, the most common mechanism of injury was a fall (55.1%), followed by being struck by or against (24.0%) (table 2). Almost 6% of injuries were work related. The most common primary body parts injured were the head/neck (23.2%), lower extremities (22.2%), and upper extremities (21.5%). The most frequent principal diagnoses were contusions/abrasions (31.4%), fractures (25.2%), and strains/sprains (15.8%).

Nearly two thirds of injured persons were mounted on horseback at the time of the event causing the injury. For those mounted, the most common mechanism was a fall (78.9%), with the most common principal diagnoses being fractures (28.0%) and contusions/abrasions (27.9%). A majority (63.9%) of injuries were either to the trunk or head/neck region. For those not mounted, the most common mechanisms were being struck by/against (56.6%) and being crushed (25.6%), and the most common principal diagnoses were contusions/abrasions (40.8%) and fractures (18.9%). A majority (60.2%) of injuries for those not mounted involved the extremities.

Based on the principal diagnosis along with injuries described in the narrative, 11.2% of those injured had a traumatic brain injury (n = 11 502; 95% confidence interval (CI), 5663 to 17 340). The narratives also suggested that 1.6% of patients were treated for hip or pelvic fractures, and 1.5% sustained spinal fractures. Most injuries (55.7%) were treated in the months of May to September, and 40.1% were treated on Saturday or Sunday (results not in table).

The two most common circumstances of injury were first, falling or being thrown by the horse while mounted (44.6%), and second, being kicked by a horse while not mounted (11.2%) (table 3). Less common circumstances of injury included falling or being thrown while mounted because the horse reared, bucked, or was spooked (7.5%), and being stepped on by the horse while not mounted (6.1%).

The distribution of injuries by primary body part affected and principal diagnosis differed for persons who were mounted and not mounted at the time of injury (table 4). Of those mounted, the most common diagnoses were traumatic brain injury (that is, concussions/internal injuries to the head) (11.9%); fractures/dislocations to the upper extremities (11.0%); fractures/dislocations to the upper trunk (9.0%); and contusions/abrasions to the lower trunk (8.0%). Of those not mounted, the most frequent diagnoses were contusions/abrasions to the lower extremities (18.2%), contusions/abrasions to the upper extremities (8.6%), fractures/dislocations to the lower extremities (7.5%), and lacerations to the head (7.2%).

DISCUSSION

Most horse related injuries occur among females, which is in contrast to other injury causes which are often more prevalent for males.[21] These injuries are quite severe, with a larger percentage admitted to hospital than for other causes of injury (11.2% *v* 5.5% for all injuries), and with a substantial number sustaining more serious diagnoses such as fractures and head injuries.[21]

The annual number of horse related injuries from 2001–2003 reported in this study (102 904) is higher than the estimates previously reported using NEISS. A study using 1990 NEISS data estimated that 74 349 persons with horse

Table 3 National estimates* of non-fatal horse related injuries treated in emergency departments, by injury circumstances†—USA, 2001–2003

Circumstance	Annual estimate	(95% CI)	Percentage
Mounted			
Fall/thrown			
And no other circumstances reported	45 875	(34 598 to 57 152)	44.6
And struck by or against object (eg, fence, tree)	1896	(993 to 2800)	1.8
And was stepped on, trampled, or kicked by horse	1277	(598 to 1956)	1.2
And horse fell/rolled	1173‡	(409 to 1938)	1.1
And other circumstance(s)	522‡	(120 to 924)	0.5
Bucked/reared/spooked			
And no other circumstances reported	153‡	(22 to 284)	0.1
And person fell or was thrown	7755	(4367 to 11 142)	7.5
And other circumstance(s)	777	(394 to 1160)	0.8
While riding			
And no other circumstances reported	1718	(1098 to 2338)	1.7
Struck against object	1915	(1169 to 2661)	1.9
And other circumstance(s)	832	(440 to 1223)	0.8
Horse tripped, fell, and/or rolled			
And no other circumstances reported	2475	(1696 to 3253)	2.4
And person fell or was thrown	1044	(425 to 1664)	1.0
And other circumstance(s)	189‡	(37 to 341)	0.2
Other/unknown circumstance(s)	425‡	(165 to 685)	0.4
Not mounted			
Kicked	11 534	(8917 to 14 150)	11.2
Stepped on	6315	(4243 to 8388)	6.1
Pushed into, pulled, jerked, or knocked down	3076	(2215 to 3938)	3.0
Bitten	1817	(1087 to 2547)	1.8
Bucked/reared/spooked	1485	(761 to 2209)	1.4
Struck by or against object	1459	(913 to 2004)	1.4
Body part caught	1279	(832 to 1725)	1.2
Hit by horse's head	1017	(616 to 1419)	1.0
Horse tripped/fell/rolled	831	(413 to 1249)	0.8
Other/unknown circumstance(s)	1475	(929 to 2021)	1.4
Mounting/dismounting			
Fell	995	(447 to 1544)	1.0
Jumped off	652	(325 to 979)	0.6
Other/unknown circumstance(s)	852	(541 to 1163)	0.8
Other/unknown mounted status	2090	(993 to 3187)	2.0

*Numbers may not add up to totals because of rounding.
†Circumstance categories are mutually exclusive. Cases were coded to the furthest level of detail known.
‡Estimate may be unstable because the coefficient of variation is more than 30%.
CI, confidence interval.

Table 4 National estimates* of non-fatal horse related injuries treated in emergency departments, by primary body part injured and principal diagnosis for those mounted or not mounted at time of injury—USA, 2001–2003

	Mounted			Not mounted		
Primary body part affected and principal diagnosis	**Annual estimate**	**(95% CI)**	**%**	**Annual estimate**	**(95% CI)**	**%**
Head/neck	16 789	(10 360 to 23 219)	24.7	6107	(4328 to 7886)	20.2
Concussion/internal injury	8068	(3685 to 12 451)	11.9	1641	(774 to 2508)	5.4
Contusion/abrasion	2675	(1801 to 3549)	3.9	1120	(686 to 1554)	3.7
Laceration	2400	(1604 to 3196)	3.5	2193	(1573 to 2812)	7.2
Other	3647	(2188 to 5106)	5.4	1153	(590 to 1716)	3.8
Upper trunk	13 747	(9956 to 17 539)	20.2	3999	(2807 to 5190)	13.2
Contusion/abrasion	4799	(3447 to 6151)	7.1	1920	(1161 to 2678)	6.3
Fracture/dislocation	6122	(4180 to 8064)	9.0	1008	(597 to 1419)	3.3
Other	2826	(1661 to 3992)	4.2	1071	(705 to 1437)	3.5
Lower trunk	12 921	(9685 to 16 157)	19.0	1832	(1246 to 2418)	6.1
Contusion/abrasion	5475	(4089 to 6861)	8.0	1196	(732 to 1660)	4.0
Strain/sprain	3653	(2469 to 4837)	5.4	275†	(100 to 449)	0.9
Other	3793	(2464 to 5123)	5.6	361†	(135 to 588)	1.2
Upper extremities	13 127	(10 028 to 16 227)	19.3	7723	(5867 to 9579)	25.5
Contusion/abrasion	2649	(1849 to 3450)	3.9	2596	(1893 to 3299)	8.6
Fracture/dislocation	7477	(5547 to 9408)	11.0	2160	(1319 to 3001)	7.1
Laceration	577	(282 to 873)	0.8	1043	(677 to 1409)	3.4
Other	2423	(1655 to 3192)	3.6	1924	(1303 to 2545)	6.4
Lower extremities	10 704	(8148 to 13 260)	15.7	10 517	(7716 to 13 318)	34.7
Contusion/abrasion	2823	(1928 to 3718)	4.1	5525	(3868 to 7182)	18.2
Fracture/dislocation	3523	(2414 to 4632)	5.2	2263	(1422 to 3104)	7.5
Strain/sprain	3426	(2453 to 4399)	5.0	1082	(637 to 1528)	3.6
Other	933	(539 to 1327)	1.4	1647	(954 to 2340)	5.4
Other/unknown body part	737	(349 to 1125)	1.1	112†	(−49 to 272)	0.4

*Numbers may not add up to totals because of rounding.
†Estimate may be unstable because the coefficient of variation is more than 30%.
CI, confidence interval.

related injuries were treated in American hospital emergency departments.[17] NEISS estimates for 2000 and 2001 (that is, 79 094 and 79 746, respectively) were reported in a newsletter for the American Medical Equestrian Association.[22] Estimates in previous reports were based only on NEISS cases with a product code indicating ''horseback riding—activity, apparel, or equipment,'' whereas our estimates also used the narratives to identify other cases with horse related injuries. Our more comprehensive definition resulted in a 10-fold increase, from 2907 to 30 288, in the annual estimated number of cases identified as injured when not mounted.

The results observed in this study are generally consistent with previous studies. First, the greater number of females with horse related injuries in this study (59%) is consistent with the percentage of females seen in previous studies (52% to 85%).[8–11 16 23] Second, the age patterns of those injured in this study are also consistent with previous studies, with most showing a peak for those aged 10 to 14 or 10 to 19 years,[9 13 23] and some showing a second peak for those aged 30 to 40.[13 23] Third, as in this study, most previous studies have found that falling/being thrown from the horse and being kicked are the two most common incidents leading to injuries.[9–12 16 24 25] Finally, the figure of 11% of patients admitted to hospital or transferred in this study corresponds to hospital admission rates in other studies (7% to 30%).[9 10 13 14 23 26–28]

Horse related injuries share some similarities and dissimilarities with other sports and recreation (SR) injuries. Both horse related and SR injuries peak among adolescents aged 10 to 14 years[4]; however, SR injuries generally do not peak a second time in the 35 to 49 year age group. Although the SR injury rate for males is twice that for females, the horse related injury rate is 1.4 times higher for females than for males. Horse related injuries are also more severe, as evidenced by 11.2% being admitted to hospital or transferred, as opposed to 2.3% for SR injuries.

Comparisons between horse related injuries and all-terrain vehicle (ATV) injuries are relevant. Both involve potentially high speeds, an ''off road'' environment, and riders external to both ''vehicles.'' Each year, about 127 000 ATV related injuries are treated in American hospital emergency departments, similar to the number of horse related injuries, and a comparable percentage is admitted to hospital or transferred (12.2% for ATV injuries *v* 11.2% for horse related injuries). The composition of serious injuries as determined by principal diagnoses is also similar, with 26.0% of ATV related patients sustaining fractures and 7.8% diagnosed as having traumatic brain injuries, compared with 25.2% and 9.7%, respectively, for patients with horse related injuries (unpublished NEISS-AIP data). Given the similarity of horse related and ATV injuries, surprisingly safety regulation/legislation only involves ATV riders (helmet use, minimum age requirements, and safety education)[29]; no such regulations exist for horseback riders.

Limitations

This study had several limitations. First, because data are lacking on the number of participants in horse related activities, injury rates were calculated based on US population estimates and could not account for different exposures to horses by age and sex. Second, because the narratives varied in detail, data were not systematically available on factors potentially associated with the injury incident, such as protective equipment use (helmets, vests); alcohol use; skill level of the rider; information about the horse's nature or behaviour; and environmental conditions. Third, NEISS–AIP data only capture injuries treated in hospital emergency departments, not injuries treated elsewhere or not at all. Fourth, NEISS–AIP data only allow one body part diagnosis to be recorded; when possible, however, other severe injuries mentioned in the narratives were coded. Finally, data are not presented by race because of the high percentage (26%) of cases with no race specified.

Implications for prevention

The frequency and severity of horse related injuries indicate that prevention programmes are needed. Measures can be taken to prevent horse related injuries, either by reducing the likelihood of incidents that may result in injuries (primary prevention: securing saddle, education) or by reducing the likelihood of injuries once an incident has occurred (secondary prevention: helmet use).

Probably the most important measure individuals can take to reduce serious injuries is to wear a helmet meeting the standards of the American Society for Testing and Materials (ASTM)/Safety Equipment Institute (SEI), such as ASTM standard F1163, or a similarly certified helmet. Currently, the American Academy of Pediatrics, the American Medical Association, the US Pony Club, and other organised groups recommend the use of ASTM/SEI helmets.[5 6 30] The mechanisms for head injury are similar to those for activities in which helmets have proven effective (riding a bicycle, motorcycle, or ATV), and many horse related studies have shown either a reduction in injuries following increased helmet use or less severe injuries among people wearing helmets.[5 7 15 31] Helmets should fit well and be properly secured.[5] Because of the risk of being kicked while not mounted, some experts have recommended wearing helmets even when not mounted for young children and for certain activities (Malavase D, personal communication); in this study, 16% of the patients with a principal diagnosis of traumatic brain injury sustained the injury while not mounted.

Unfortunately, there are no current estimates of equestrian helmet use in the USA. The latest survey conducted in 1991 estimated that 43% of riders wore helmets at least some of the time.[31] Identified barriers to helmet use (for example, low risk perception, lack of comfort and style) apply to both equestrian and bicycle helmets[31 32]; promotion strategies identified for bicycle helmets may also be successful in promoting helmets for horse related activities.[33 34]

Previous recommendations emphasise wearing appropriate riding attire. Sturdy boots with a heel should be worn to prevent the feet from slipping through the stirrup.[3 5 6 24 27 35–38] Gloves of non-skid material may also be worn.[5 35 39] Loose fitting clothes should be avoided and hair should be tied back to avoid entanglement with branches and other obstacles.[3 6 27 36]

Other safety equipment has been suggested, although the protective effects have not been proven. Safety stirrups that release when a certain amount of pressure is applied may prevent a rider from being dragged. Though recommended by some experts,[9 37] others question whether they are effective.[5 35 36] In this study, more than 350 people were injured each year when a foot was caught in a stirrup. Additionally, body protector vests may protect the spinous processes and ribs from kicks and falls.[36] While mandatory for certain events in Britain,[25] the effectiveness of such vests has not been evaluated.[5] An ASTM standard for these vests has been established (ASTM F1937).

Individuals should be in the proper physical and mental condition to ride or work around horses.[35] Riding requires balance, agility, mental acuity, and a reasonable level of physical fitness.[5 40] Alcohol should not be consumed when riding or working with horses.[40] Previous studies have found that of those tested, 17% of horse related hospital admissions[12] and 33% of deaths[39] involved a detectible blood alcohol level. In this study, less than 1% of unweighted cases (34) were reported to involve alcohol use. However, alcohol use was probably underreported because the information was not routinely collected in NEISS-AIP.

Education by trained instructors may help prevent horse related injuries.[5 6 17 24 27 30 40] Horses are a prey species whose actions can be better understood and predicted when the animal's instincts are considered. For example, horses can be spooked when exposed to new experiences or perceived threats (for example, a person walking into a horse's blind spot).[38] Additionally, experts recommend instruction in proper falling techniques.[5 24 27 36 40]

Aside from protective equipment, appropriate clothing, and training, other safety measures should be considered when preparing to ride. One should ensure that the horse is in good health and appropriately matched to the rider's abilities.[3 5 30 37 40] Additionally, inspect all tack to ensure that it is correctly applied.[3 5 6 27 40] In this study, an estimated 550 people were injured each year when the saddle slipped or broke. Riders and others working with horses should avoid wrapping the reins, lead, or rope around their hands.[37 38] An estimated 2000 people in this study were injured annually when their hands or fingers were caught in the horse's tack.

Riding organisations and stables can influence proper horse riding and handling by instituting regulations or guidelines regarding helmet use, appropriate attire, rider education, and supervision to create an atmosphere where safe practices are routine. Previous researchers suggest that children and inexperienced riders should be adequately supervised,[5 37] and children under six should not be allowed to ride independently.[6] In addition, riding environments can be modified to reduce the risk of injury (for example, energy absorbing riding surfaces[5]). Finally, previous researchers recommend having medical care available at organised events,[5 41 42] along with having an emergency plan for daily operations including first aid training for personnel and the availability of emergency supplies.[43]

Riders, equestrian organisations, and health care providers have opportunities to prevent horse related injuries by counselling those involved in these activities. Stressing injury prevention to persons who have experienced an injury may be beneficial because reinjury rates are reportedly high, with 25% to 37% of injured persons having had a previous injury.[9 10 23 28] Because of the frequency of concussions during horse related activities and the concern regarding repeated concussions, the use of return-to-play guidelines similar to those used in contact sports is relevant.[24 44]

What is already known on this topic

- Previous studies suggest that horse-related injuries can be severe and are more frequent in females, particularly those ages 10-14 years

What this study adds

- Over 100 000 people with horse related injuries are treated in American emergency departments annually. Using a national sample, this study characterises these injuries overall, and when mounted or not mounted
- Horse related injuries can be severe as evidenced by higher percentages of hospital admissions, fractures, and traumatic brain injuries when compared with other recreation related injuries

Conclusions

This study shows that horse related injuries are a serious issue, particularly for young females. The hospital admission rate and the percentage of people with potentially severe diagnoses underscores the need for prevention efforts. Prevention programmes should target helmet use as well as education and training about horse behaviour, and safe horse handling and riding. Additional research is needed to evaluate the effectiveness of specific interventions to reduce the number and severity of horse related injuries.

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Non-fatal horse related injuries treated in emergency departments in the United States, 2001–2003

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