FROM CHITWAN TO VIENNA. HOW DO GAIT PARAMETERS CHANGE IN A PAIR OF INDIAN RHINOS (*RHINOCEROS UNICORNIS*) COMING FROM SEMI-WILD CONDITIONS TO A EUROPEAN ZOO?

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Abstract

The Indian rhino (*Rhinoceros unicornis*) is generally regarded a species with few health problems[1]. However, one problem is prevalent and has been thoroughly studied by von Houwald[2], the so-called Chronic foot disease (CFD). CFD is thought to be completely husbandry related. It is characterized by non-healing fissures and ulcers, most prominent between the central toe and the pad, by pad overgrowth, bruising and chronic infection[2]. Thorough analysis of gait characteristics can increase the understanding of Indian rhino gait and aid in early detection and treatment of CFD.

The goal of this study was to monitor gait characteristics in a pair of Indian rhinos one female (*2003) and one male (*1997) coming from the semi-wild conditions of the wildlife orphanage at Chitwan National Park in Nepal to a European Zoological Garden, the Zoo in Vienna, Austria, and determine the parameter that changed over time due to husbandry conditions.

Kinetic data were collected during normal gait with a pressure measurement system (Tekscan Walkway 4, Savecomp Megascan GmbH) between June 2006 and March 2011. 23 gait parameters were recorded.

Parallel changes over time could be observed in both animals in the location of the Center of Force (COF), the contact area, and in the central toes. A palmar/plantar shift of the COF (from a relative longitudinal position of ~43% to ~51% of the entire hind foot-length in both animals) was caused by a bodymass increase during the first year (in the male 190 kg, in the female 191 kg). In the following years this trend reversed resulting in a dorsal shift of the COF (to ~37% of the entire hind foot-length in the male and less than 35% in the female) and a substantial decrease in contact area during stance (from ~325 cm^2 to ~165 cm^2 in the average male hind foot and from ~230 cm^2 to ~130 cm^2 in the average female hind foot). The cause is excessive sole abrasion, especially on the central toes in the hind feet of both animals. Outgrowth of the central toes in the hind feet in both animals was observed by fall of 2008 in the male by ~1 cm and by spring of 2009 by more than 2 cm in the female. An increased length of the central toe increases the shear forces during pushing off, placing strain on the area of the pad adjacent to the central toe, where CFD usually starts to develop [2].

The reason for the outgrowth of the toe and the dorsal shift of the COF being more severe in the female is unclear but could be due to different activity[3], to age or might be individual. Genetic predisposition, neonate nutrition, hormonal differences as well as overall body structure and conformation might be factors that need to be taken into account.

Both animals share the same habitat, the same keeper routine and nutrition. Therefore it can be concluded that captive conditions, especially abrasive surfaces, at Vienna Zoo caused a change in the foot anatomy of the two Indian Rhinos coming from Chitwan Nationalpark, Nepal.

Introduction

The Indian rhino has a long tradition of being in human care, has strict husbandry guidelines, and is generally regarded as a species with few health problems[1]. One is prevalent though and has been thoroughly studied by von Houwald[2], the so-called Chronic foot disease (CFD). It is characterized by non-healing fissures and ulcers, most prominent between the central toe and the pad, by pad overgrowth, bruising and chronic infection[2]. 25% of all Indian Rhinos in the United States and Europe are affected by CFD; the disease most commonly appears in males, in hind feet, and between the age of 7 and 11 years[4]. CFD is thought to be completely husbandry related. No wild animals have been found with CFD[5]. Guldenschuh and von Houwald [1] stated that "Indian Rhinos are sole-walkers, meaning that they use sole and weight bearing border of their digits for bearing weight….Captive conditions (abrasive materials for indoor enclosures, overfeeding) have lead to a change in the foot anatomy and turned them into a pad-walker with a weight shift palmar/plantar to the mid part of the footpad." A central goal of all Indian rhino holders is to minimize the occurrence of CFD through continuously improving husbandry to avoid a change in a suspected change in foot anatomy.

The goal of this study was to monitor gait characteristics in a pair of Indian rhinos coming from the semi-wild conditions of the rhino orphanage at Chitwan National Park in Nepal to a European Zoological Garden, the Zoo in Vienna, Austria, and determine the parameter that changed over time due to husbandry conditions.

For the first time in this study kinetic gait parameters are collected in Indian Rhinos. A thorough understanding of the characteristics of the Indian rhino's gait can aid in detecting and successfully treating CFD. In horses gait analysis is already used as a clinical tool to reveal deviations of a certain gait patterns as indication for clinical problems within the muscoskeletal system, even before severe signs of pain are exhibited by the animal[6].

Methods

The two animals of Vienna Zoo are wild born and arrived at the institution in March of 2006. The male Jange was found in the Sagul Tol region in July of 1997 at the age of approximately 6 months of age. He was held in a paddock at the Chitwan wildlife orphanage, equipped with natural ground and a mud pool. Several trials of reintroduction failed. At his arrival in Vienna he was completely blind on the right eye and his visual capability on the left eye was at an estimated 20%. Veterinary investigations revealed that this damage was an old infection (Nell, Veterinary University Vienna, personal communication). According to the age classification of Dinerstein [7] he was regarded as young adult until 2008, afterwards as an animal of intermediate age.

The female Sundari is also an orphan. She was found in Chitwan in October 2003, also only few months of age and was also hand-raised in the same wildlife orphanage. She was regarded as too attached to humans to be reintroduced again. Her paddock contained no pool. She was still categorized as a calf until 2008, regarded as subadult until March of 2009, and afterwards as young adult [7].

The indoor enclosure of the rhino exhibit at Vienna Zoo is split into three parts. All together the area accessible to the animals is 380 m^2 in size. All enclosures are equipped with an automated drinking trough. The two larger enclosures contain a heated pool (68 m^2 and 65 m^2 respectively) with a shower and a mud wallow (44 m^2 and 9 m^2 respectively). The floor is covered with a 3-layered rubber coating that was poured onto a concrete surface. The top coat of the rubber layer contains an overspray of 1mm with small hard rubber particles to prevent slipping when the surface is wet. Temperature and humidity are kept quite stable at around 23°C and between 50 – 60%.

The animals are able to enter the outside enclosure either directly through a gate in the medium sized enclosure or through a walkway alongside the enclosures. The outside enclosure measures 5005 m^2 and is also split into three parts of different sizes and separated by steel poles, spaced between 30 and 45 cm. The smaller part is home to Axis deer (*Axis axis*), blackbuck (*Antilope cervicapra*) and Nilgai (*Boselaphus tragocamelus*). The antelopes and deer can access the rhinos' enclosures through the poles and retreat if they wish to. Both outside rhino enclosures are equipped with pools and mud wallows, as well as elevated feeding platforms of wood and rock. Structures like rocks or large tree trunks were placed within the enclosures. The ground is in parts natural, partly covered with sand, partly covered with bark mulch, and in parts pressed to prevent hoof problems in deer and antelopes.

The animals were fed in the morning around 7:00 or 7:30 am. Around 9.00 am a veterinary target training session for health checks is carried out one to three times a week. Shortly after 10.00 am the animals were shifted to the outside enclosure where fresh browse and grass, straw or hay is provided. If the ground was frozen, the animals remain in the holding area just outside the inside enclosure, since this part is roofed and remains dry during bad weather. During winter the animals came back to the inside enclosure just before noon, were fed again, and stayed inside until 1.15 pm. If weather conditions allowed, the animals were brought outside again until 4.00 pm. Then they were placed inside for the night. During summer, the animals normally remained outside the entire day, they were fed outside around noon, fed inside at around 3.30 pm and after that are free to go outside or stay inside for the night. [3]
Foot condition was controlled regularly during training sessions, bodymass was controlled regularly.

Kinetic data were collected with a pressure plate system (Tekscan Walkway 4, Savecomp Megascan GmbH), consisting of four embedded 7100 Sensors, á 45 cm x 50 cm, providing an overall measuring area of 90 cm x 100 cm, with four pairs of dual handles. Spatial resolution was 0.64 mm x 0.64 mm, measuring frequency 39 Hz.

The animals were requested to walk as straight as possible with no stops and at normal speed across the pressure plate. Measurements were regarded as valid when the gait appeared smooth and when at least one foot stepped on the plate entirely. Long term measurements were taken weekly or biweekly between June 2006 and June 2007 and were embedded into the daily routine. Data were taken when the animals were shifted from the inside to the outside enclosure and vice versa. For some analyses the data of the first year were grouped into three to ensure that sample size was large enough and resolution was still good. Additional sampling with an aimed sample size of N=10 were performed after that in fall of 2008- 2010 and in spring of 2009-2011.

Footprints were saved separately and 23 parameters were extracted for each foot. Parameter included stance duration (s), Impuls (N*s), Mean force (N), Overall force (N), Maximum force (N), maximum and minimum forces occurring in hind feet during contact landing/stance support (P1) and push off/break over (P2) phases, their occurrence within the stance duration (%), the COF trajectory, the medio-lateral and dorso-palmar/plantar position of the COF, foot length and width (cm), the length of the central toe (cm), Peak contact area (cm^2), Maximum contact area (cm^2), the occurrence of the maximum contact area within stance duration (%), Front and hind foot overlap, and the presence or absence of a central toe concavity.

All data were compiled separately for each foot. The values of the valid runs within the respective data collection periods were then averaged for further analyses. Due to the small sample size of animals, their different sex and age statistical analysis could not be carried out. Data were analysed descriptively.

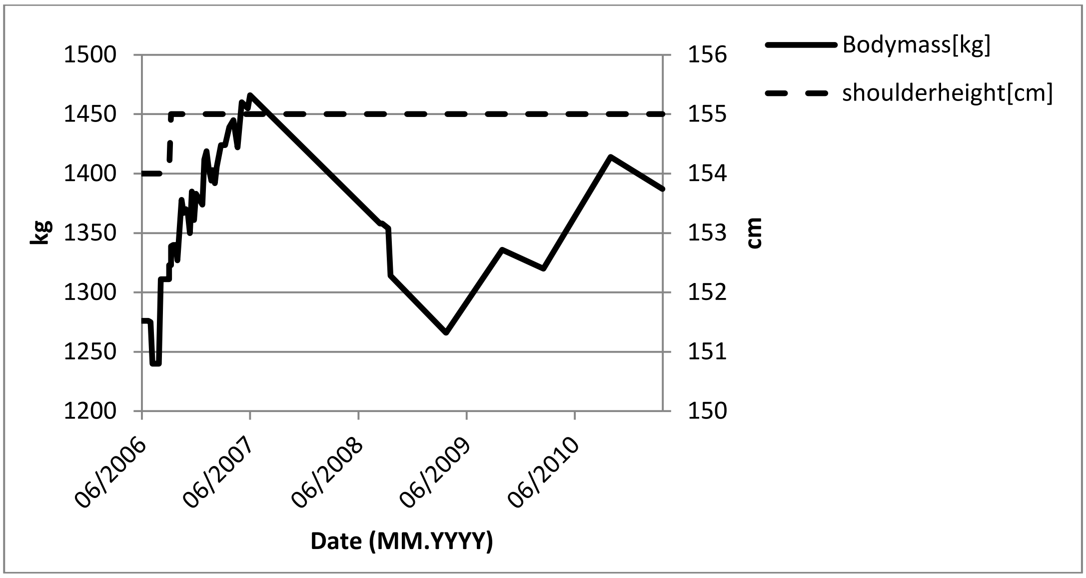

Figure 1: Body mass (kg) and height of the withers (cm) of male Jange.

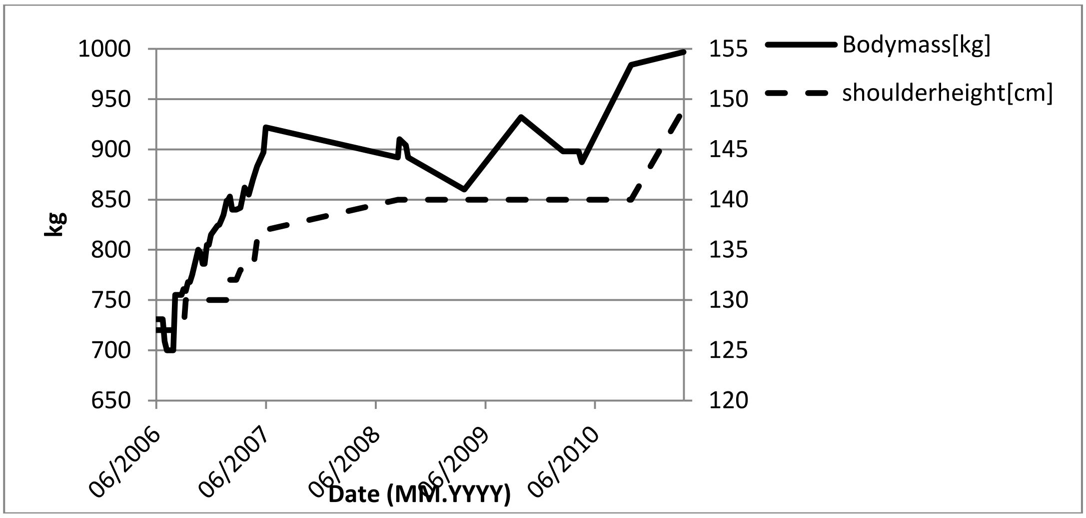

Figure 2: Body mass (kg) and height of the withers (cm) of female Sundari.

Table 1: Sample size of each foot throughout data collection periods

	Male Jange				Female Sundari			
	Front right	Front left	Hind right	Hind left	Front right	Front left	Hind right	Hind left
June – Sep. 06	30	22	29	22	33	22	29	22
Oct. 06 – Jan. 07	18	21	20	20	18	21	20	20
Feb. – May 07	13	25	10	22	13	25	10	22
Aug./Sept. 08	8	6	7	5	9	7	7	9
March 09	14	10	14	10	12	15	12	14
Sept. 09	11	13	12	11	13	13	15	11
Feb. 2010	17	12	15	10	12	13	11	11
Sept. 2010	10	14	10	14	14	9	14	10
March 2011	9	8	9	9	13	10	13	10

Results

The goal of the study was to determine if gait parameters changed over time due to husbandry conditions. Parallel changes that were observed in both animals included peak and maximum contact area, the dorso-palmar/plantar shift of the COF, a change in the shape of the sole of the central toe, and an elongation of the central toe.

On recordings from the pressure plate peak contact area was defined as the largest contact area over all contact frames of a footprint. Maximum contact area on the other hand was the largest contact frame within a footprint. A substantial decrease over time was seen in both animals in all four feet in peak (Figure 3; Figure 4; Table 2; Table 3) and maximum contact area (Table 2; Table 3). Whereas the male showed the largest contact area during the first and second data collection periods, the female exhibited the largest in fall of 2008. Largest peak contact area was 387 cm^2 in the male front left foot. During the last data collection periods in 2010 and 2011 peak contact area had decreased by about 180 cm^2 in the hind feet. Peak contact area decrease over time was also about 130 cm^2 in the female hind left foot, reaching its largest in fall of 2008 with 251 cm^2 and its smallest in March of 2011 with 120 cm^2. Maximum contact area was largest in the male's front left foot (340 cm^2) in the first data collection period in 2006. It decreased again by about 100 cm^2 over time. Decrease of maximum contact area in the hind right foot was in the hind 161 cm^2. Maximum contact area in the female was again largest in fall of 2008 (front left foot: 253 cm^2). The decrease in maximum contact area in the female's hind left foot was 130 cm^2 from fall of 2008 until spring of 2011. (Table 3; Table 2)

Parallel to a decrease in contact area a dorso-palmar/plantar shift of the COF could be observed. The COF was measured in centimeters in a parallel line to maximum foot length, starting dorsally and calculated as percentage of the entire foot length. In both animals the COF shifted palmar/plantar during the first year (Figure 5; Figure 6; Table 2; Table 3). At their arrival at Vienna Zoo the location of the COF in the front feet was between 47% (male: front left) and 45% (female: front left) and shifted palmar to a maximum of 51% (male: front left) and 50% (female: front left). In the hind feet COF was located at 43% in the male and between 43 and 45% in the female. By spring of 2007 the COF had shifted to almost 52% in the male's hind left foot and to around 50% in the female's hind feet. At the same time body mass increased by 190 kg in the male and 191 kg in the female (Figure 1; Figure 2). During the following data collection periods the COF shifted dorsally (Figure 5; Figure 6; Table 2; Table 3). In March of 2011 the COF could be found in the male's hind right foot at 36% in both of the female's hind feet at 34%.

The central toe of each foot was measured at its longest extension at peak setting of the recording. In both animals the length of the central toe had increased by fall of 2008 (male: from 5,7 cm to 6,9 cm, female: from 5,00 cm to 6,8 cm). Whereas in the female especially the central toes in the hind feet continued to elongate to a maximum of 7,4 cm in February of 2010, the males did not show a clear increase anymore and even returned close to its length at his arrival by March of 2011. During the last two data collection sessions hind central toes in the female had decreased again as well and was then equal in length to the male's. (Table 2; Table 3)

The shape of the sole of the central toe was categorized into three groups. Concavity of the sole of the central toe was deemed present when the center of the sole exhibited less than 25% of the force of the rim. Concavity was generally more often visible in the anterior feet. A 'claw-shape' of the central toe – only the dorsal rim of the central toe exerting force – was only seen in the beginning of data collection. Also, concavity of the central toes in the hind feet in both animals could only be detected during the first year. Except for fall 2008 concavity was more visible in fall data collection periods than in spring. (Table 4)

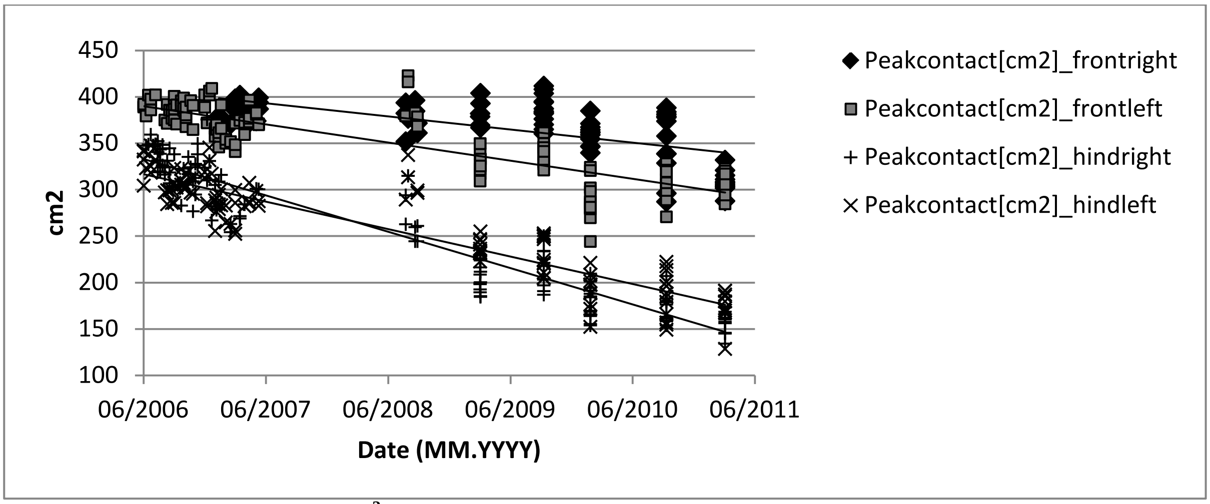

Figure 3: Peak contact area (cm^2) in all four feet of male Jange. Peak contact area is the largest contact area of all contact frames of one footprint.

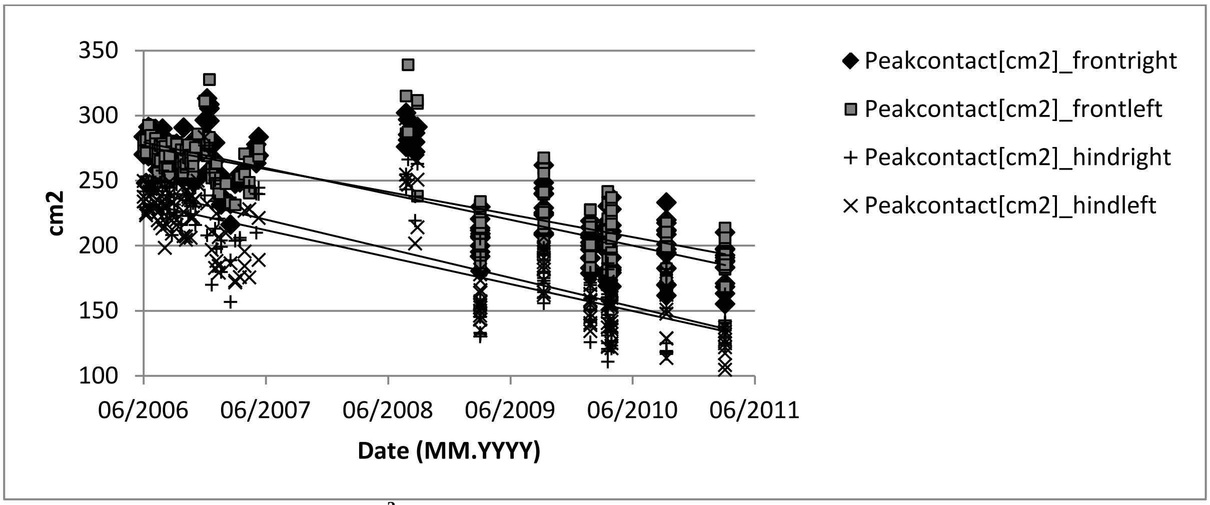

Figure 4: Peak contact area (cm^2) of all four feet of female Sundari. Peak contact area is the largest contact area of all contact frames of one footprint.

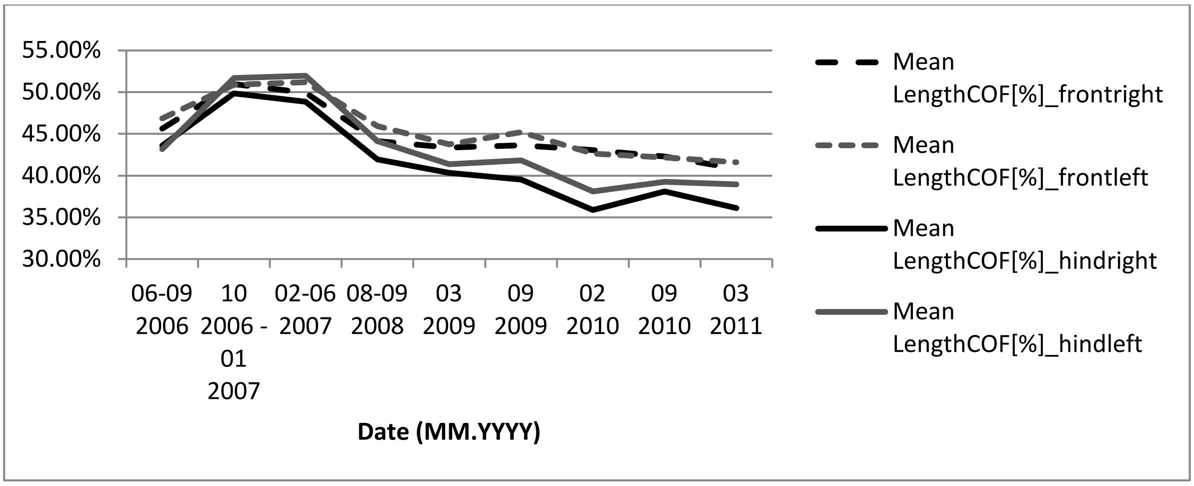

Figure 5: Mean dorso-palmar/plantar shift of the COF in the male Jange in timegroups (MM.YYYY). The COF was measured in centimeters in a parallel line to maximum foot length, starting dorsally and calculated as percentage of the entire foot length.

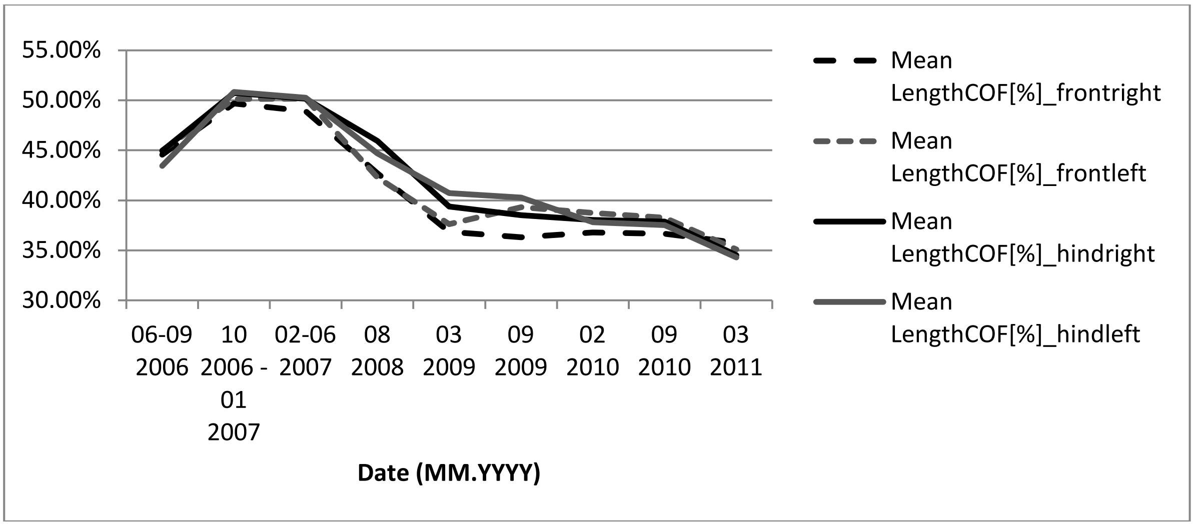

Figure 6: Mean dorso-palmar/plantar shift of the COF in the female Sundari in timegroups (MM.YYYY). The COF was measured in centimeters in a parallel line to maximum foot length, starting dorsally and calculated as percentage of the entire foot length.

Table 2: Male Jange. Averaged values of gait parameters for each timegroup (MM.YYYY)

	06-09 2006	10 2006 - 01 2007	02-06 2007	08-09 2008	03 2009	09 2009	02 2010	09 2010	03 2011
Stance duration (s): frontright	1,77 ± 0,35	1,46 ± 0,20	1,51 ± 0,13	1,49 ± 0,12	1,36 ± 0,17	1,36 ± 0,23	1,07 ± 0,12	1,28 ± 0,10	1,20 ± 0,07
Stance duration (s): frontleft	1,66 ± 0,27	1,43 ± 0,16	1,47 ± 0,22	1,37 ± 0,21	1,38 ± 0,27	1,36 ± 0,23	1,06 ±0,12	1,24 ± 0,09	1,22 ± 0,07
Stance duration (s): hindright	1,35 ± 0,17	1,25 ± 0,16	1,24 ± 0,17	1,25 ± 0,10	1,17 ± 0,13	1,21 ± 0,19	0,92 ± 0,07	1,17 ± 0,12	1,10 ± 0,05
Stance duration (s): hindleft	1,32 ± 0,19	1,25 ± 0,08	1,26 ± 0,16	1,22 ± 0,13	1,16 ± 0,13	1,21 ± 0,14	0,98 ± 0,08	1,14 ± 0,06	1,07 ± 0,06
Peak contact area (cm2): frontright	382,94 ± 11,84	385,75 ± 14,71	362,84 ± 13,38	360,84 ± 21,70	305,03 ± 12,06	332,03 ± 13,07	287,33 ± 16,18	285,88 ± 17,56	284,33 ± 11,67
Peak contact area (cm2): frontleft	386,66 ± 9,45	386,56 ± 14,14	366,77 ± 13,53	391,23 ± 20,46	329,29 ± 12,63	340,13 ± 10,47	288,11 ± 20,65	307,24 ± 15,60	307,06 ± 13,50
Peak contact area (cm2): hindright	334,57 ± 15,14	315,50 ± 25,51	284,57 ± 19,81	268,68 ± 24,28	206,16 ± 14,83	217,48 ± 20,42	178,65 ± 16,21	172,05 ± 15,36	155,01 ± 10,51
Peak contact area (cm2): hindleft	315,17 ± 19,16	305,59 ± 18,78	283,08 ± 13,70	307,10 ± 16,99	237,65 ± 8,91	230,55 ± 18,68	191,25 ± 18,86	187,52 ± 22,85	174,71 ± 18,38
Maximum contact area (cm2): frontright	338,63 ± 13,62	331,27 ± 17,47	301,38 ± 18,39	308,06 ± 19,21	248,64 ± 13,32	269,82 ± 14,15	217,71 ± 12,45	223,07 ± 17,97	214,14 ± 9,00

Maximum contact area (cm2): frontleft	339,91 ± 13,43	334,86 ± 16,85	305,36 ± 19,80	339,10 ± 16,62	275,03 ± 16,06	284,80 ± 12,89	225,33 ± 17,92	239,89 ± 14,21	230,87 ± 8,75
Maximum contact area (cm2): hindright	267,90 ± 12,29	255,26 ± 23,18	222,91 ± 17,69	219,94 ± 22,12	155,93 ± 13,90	168,28 ± 15,90	122,98 ± 13,13	121,19 ±13,31	106,52 ± 7,62
Maximum contact area (cm2): hindleft	259,11 ± 13,94	250,14 ± 17,90	229,67 ± 18,34	253,62 ± 12,98	185,71 ± 11,22	177,95 ± 17,61	137,42 ± 15,46	130,31 ± 18,93	111,83 ± 12,25
Longitudinal position of COF (%): frontright	45,62 ± 0,02	50,94 ± 0,01	49,92 ± 0,01	44,12 ± 0,03	43,35 ± 0,02	43,65 ± 0,02	43,05 ± 0,03	42,30 ± 0,03	40,84 ± 0,01
Longitudinal position of COF (%): frontleft	46,84 ± 0,02	50,87 ± 0,02	51,19 ± 0,01	45,91 ± 0,01	43,73 ± 0,02	45,21 ± 0,02	42,63 ± 0,03	42,18 ± 0,05	41,85 ± 0,02
Longitudinal position of COF (%): hindright	43,58 ± 0,03	49,83 ± 0,02	48,85 ± 0,01	41,96 ± 0,03	40,34 ± 0,03	39,53 ± 0,03	35,90 ± 0,04	38,11 ± 0,03	36,12 ± 0,02
Longitudinal position of COF (%): hindleft	43,15 ± 0,03	51,67 ± 0,01	51, 94 ± 0,02	44,14 ± 0,02	41,38 ± 0,03	41,81 ± 0,03	38,10 ± 0,02	39,25 ± 0,03	38,95 ± 0,02
Length of central toe (cm): frontright	5,85 ± 0,62	5,91 ± 0,49	6,26 ± 0,46	6,45 ± 0,50	6,75 ± 0,46	6,97 ± 0,38	6,68 ± 0,52	6,69 ± 0,44	6,79 ± 0,30
Length of central toe (cm): frontleft	5,95 ± 0,48	5,87 ± 0,37	6,24 ± 0,45	6,20 ± 0,47	6,36 ± 0,36	6,61 ± 0,56	6,73 ± 0,52	6,71 ± 0,33	6,46 ± 0,29
Length of central toe (cm): hindright	5,92 ± 0,29	5,92 ± 0,42	5,81 ± 0,37	6,34 ± 0,31	6,49 ± 0,24	6,02 ± 0,44	6,29 ± 0,43	5,84 ± 0,37	6,10 ± 0,29
Length of central toe (cm): hindleft	5,74 ± 0,36	5,87 ± 0,41	5,88 ± 0,39	6,90 ± 0,18	6,47 ± 0,62	6,19 ± 0,67	6,96 ± 0,38	6,57 ± 0,28	5,88 ± 0,45
Percentage of central toe of the foot length (%): frontright	21,38 ± 0,02	21,31 ± 0,02	22,58 ± 0,02	23,04 ± 0,02	24,91 ± 0,02	25,80 ± 0,01	24,87 ± 0,02	25,09 ± 0,02	25,44 ± 0,01
Percentage of central toe of foot length (%): frontleft	22,17 ± 0,02	21,53 ± 0,01	22,00 ± 0,05	22,49 ± 0,01	23,61 ± 0,01	24,74 ± 0,02	25,40 ± 0,02	24,89 ± 0,01	24,52 ± 0,01
Percentage of central toe of foot length (%): hindright	20,82 ± 0,04	21,26 ± 0,01	21,16 ± 0,01	22,89 ± 0,01	23,85 ± 0,01	22,25 ± 0,01	22,87 ± 0,01	22,12 ± 0,01	23,19 ± 0,01
Percentage of central toe of foot length (%): hindleft	21,84 ± 0,01	21,50 ± 0,01	21,67 ± 0,01	24,80 ± 0,01	24,70 ± 0,02	23,81 ± 0,01	25,73 ± 0,01	24,51 ± 0,01	22,46 ± 0,01

Table 3: Female Sundari. Averaged values of gait parameters for each timegroup (MM.YYYY)

	06-09 2006	10 2006 - 01 2007	02-06 2007	08-09 2008	03 2009	09 2009	02 2010	09 2010	03 2011
Stance duration (s): frontright	1,06 ± 0,18	1,07 ± 0,28	1,17 ± 0,17	1,20 ± 0,19	1,13 ± 0,17	1,15 ± 0,23	1,02 ± 0,08	1,06 ± 0,08	1,11 ± 0,12
Stance duration (s): frontleft	1,18 ± 0,32	1,09 ± 0,23	1,18 ± 0,19	1,18 ± 0,20	1,11 ± 0,17	1,32 ± 0,23	1,11 ± 0,13	1,06 ± 0,06	1,08 ± 0,06
Stance duration (s): hindright	0,97 ± 0,15	0,94 ± 0,18	1,04 ± 0,14	1,12 ± 0,20	1,02 ± 0,13	1,01 ± 0,14	0,93 ± 0,07	0,93 ± 0,07	0,99 ± 0,06
Stance duration (s): hindleft	1,04 ± 0,23	0,93 ± 0,11	1,04 ± 0,19	1,06 ± 0,16	0,94 ± 0,08	1,08 ± 0,18	0,97 ± 0,11	0,92 ± 0,04	0,98 ± 0,10
Peak contact area (cm2): frontright	268,46 ± 21,12	278,36 ± 17,85	253,98 ± 17,49	285,79 ± 9,19	204,88 ± 13,13	231,15 ± 15,82	199,96 ± 11,84	198,21 ± 20,29	183,88 ± 14,86
Peak contact area (cm2): frontleft	270,72 ± 12,52	273,37 ± 19,36	252,20 ± 12,50	298,17 ± 29,59	213,61 ± 14,44	235,79 ± 19,74	204,39 ± 14,43	200,26 ± 13,48	189,52 ± 14,29
Peak contact area (cm2): hindright	237,81 ± 11,81	239,65 ± 25,94	209,50 ± 24,43	247,93 ± 14,92	158,02 ± 22,82	181,20 ± 13,71	157,86 ± 16,33	151,17 ± 24,80	137,13 ± 9,90
Peak contact area (cm2): hindleft	229,46 ± 11,83	229,21 ± 22,72	195,45 ± 19,41	251,16 ± 27, 86	157,29 ± 13,33	185,76 ± 13,70	151,74 ± 10,56	151,38 ± 20,31	120,57 ± 12,81
Maximum contact area (cm2): frontright	235,07 ± 14,90	234,97 ± 17,29	207,85 ± 20,43	250,67 ± 13,84	161,88 ± 17,33	187,00 ± 15,78	153,33 ± 8,56	153,33 ± 15,29	134,61 ± 8,34
Maximum contact area (cm2): frontleft	237,08 ± 15,70	224,09 ± 23,27	205,22 ± 14,23	253,12 ± 31,11	172,54 ± 14,50	186,70 ± 18,36	154,04 ± 10,90	149,33 ± 10,54	136,03 ± 9,71
Maximum contact area (cm2): hindright	195,69 ± 12,97	194,82 ± 26,19	161,36 ± 22,88	203,94 ± 15,57	114,69 ± 17,70	129,74 ± 13,71	106,37 ± 12,75	98,99 ± 18,74	85,99 ± 8,04
Maximum contact area (cm2): hindleft	184,25 ± 13,94	179,38 ± 20,31	146,66 ± 17,80	203,95 ± 28,87	107,80 ± 11,97	127,39 ± 14,98	98,89 ±10,74	96,31 ± 17,43	73,99 ± 5,06
Longitudinal position of COF (%): frontright	44,55 ± 0,03	49,67 ± 0,01	48,91 ± 0,01	42,71 ± 0,01	36,87 ± 0,02	36,31 ± 0,02	36,80 ± 0,02	36,65 ± 0,02	35,77 ± 0,02
Longitudinal position of COF (%): frontleft	44,97 ± 0,03	50,11 ± 0,02	50,17 ± 0,02	42,29 ± 0,02	37,64 ± 0,02	39,32 ± 0,03	38,74 ± 0,02	38,26 ± 0,02	35,10 ± 0,04
Longitudinal position of COF (%): hindright	44,96 ± 0,03	50,73 ± 0,02	50,15 ± 0,02	45,95 ± 0,02	39,38 ± 0,02	38,51 ± 0,03	38,05 ± 0,03	37,88 ± 0,08	34,52 ± 0,02
Longitudinal position of COF (%): hindleft	43,45 ± 0,07	50,82 ± 0,02	50,25 ± 0,02	44,68 ± 0,02	40,72 ± 0,02	40,28 ± 0,03	37,82 ± 0,01	37,52 ± 0,03	34,28 ± 0,02
Length of central toe (cm): frontright	4,64 ± 0,50	4,83 ± 0,54	5,44 ± 0,30	5,64 ± 0,49	6,08 ± 0,25	5,95 ± 0,35	6,32 ± 0,19	5,91 ± 0,50	5,82 ± 0,29
Length of central toe (cm): frontleft	4,89 ± 0,35	5,04 ± 0,34	5,47 ± 0,32	6,09 ± 0,49	6,19 ± 0,29	6,15 ± 0,31	6,55 ± 0,23	6,76 ± 0,25	6,45 ± 0,34
Length of central toe (cm): hindright	5,00 ± 0,43	5,54 ± 0,52	5,75 ± 0,34	6,86 ± 0,15	7,20 ± 0,44	6,91 ± 0,55	7,38 ± 0,33	6,47 ± 0,45	6,35 ± 0,50

Length of central toe (cm): hindleft	4,81 ± 0,35	4,89 ± 0,58	5,39 ± 0,32	6,47 ± 0,27	7,13 ± 0,32	6,95 ± 0,62	7,02 ± 0,16	6,78 ± 0,36	6,25 ± 0,53
Percentage of central toe of the foot length (%): frontright	19,96 ± 0,02	19,94 ± 0,02	22,57 ± 0,01	23,55 ± 0,02	25,47 ± 0,01	24,77 ± 0,01	26,39 ± 0,01	25,04 ± 0,02	24,60 ± 0,01
Percentage of central toe of foot length (%): frontleft	20,82 ± 0,01	21,23 ± 0,01	23,01 ± 0,02	24,61 ± 0,02	25,91 ± 0,01	25,61 ± 0,01	27,28 ± 0,01	28,60 ± 0,01	25,98 ± 0,02
Percentage of central toe of foot length (%): hindright	21,16 ± 0,02	22,60 ± 0,02	23,37 ± 0,01	26,94 ± 0,01	28,26 ± 0,02	27,52 ± 0,02	29,19 ± 0,01	26,93 ± 0,05	23,87 ± 0,07
Percentage of central toe of foot length (%): hindleft	20,58 ± 0,02	20,36 ± 0,02	22,19 ± 0,01	25,68 ± 0,01	28,15 ± 0,01	28,02 ± 0,02	28,09 ± 0,01	27,18 ± 0,01	25,43 ± 0,02

Table 4: Relative occurrence of recorded central toe shapes per timegroup (MM.YYYY) and category. Concavity was deemed present when the center of the sole of the central toe was less than 25% of the force of the rim. Claw-shape was present when only the dorsal rim of the central toe was visible.

Timegroup	Male Jange				Female Sundari			
	claw				claw			
	Centraltoe frontright	Centraltoe frontleft	Centraltoe hindright	Centraltoe hindleft	Centraltoe frontright	Centraltoe frontleft	Centraltoe hindright	Centraltoe hindleft
06-09 2006	51,72%	20,83%		13,64%	5,41%	2,70%		
10 2006 - 01 2007		4,55%						
02-06 2007								
08-09 2008								
03 2009								
09 2009								
02 2010								
09 2010								
03 2011								
	concave				concave			
06-09 2006	37,93%	33,33%	51,72%	4,55%	51,35%	45,95%	3,23%	
10 2006 - 01 2007	27,78%	22,73%			3,85%	17,24%		
02-06 2007	7,69%	25,00%			11,54%	11,54%		
08-09 2008								
03 2009		11,11%			28,57%	30,77%		
09 2009	20,00%	53,85%			38,46%	69,23%		
02 2010	5,88%							
09 2010	40,00%	78,57%	10,00%		100,00%	100,00%		
03 2011								
	not concave				not concave			
06-09 2006	10,34%	45,83%	48,28%	81,82%	43,24%	51,35%	96,77%	100,00%
10 2006 - 01 2007	72,22%	72,73%	100,00%	100,00%	96,15%	82,76%	100,00%	100,00%
02-06 2007	92,31%	75,00%	100,00%	100,00%	50,00%	50,00%	100,00%	100,00%
08-09 2008	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
03 2009	100,00%	88,89%	100,00%	100,00%	71,43%	69,23%	100,00%	100,00%
09 2009	80,00%	46,15%	100,00%	100,00%	61,54%	30,77%	100,00%	100,00%
02 2010	94,12%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
09 2010	60,00%	21,43%	90,00%	100,00%			100,00%	100,00%
03 2011	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

Discussion

Kinetic and kinematic gait analysis are well established methods in domestic animals such as horses, cattle or pigs, but also dogs to better understand the pressure and force distribution and gait in sound animals [8, 9] or measure the effects of different flooring on gait [10-12]. Since

Indian rhinos are most closely related to the equine family [13] many of the results gained from equine studies can be transferred to the rhinos and therefore most citations and comparisons are made to horses.

Generally, attention has to be paid regarding distance measurements, for example on foot length and width or central toe length. Those measurements need not necessarily reflect true (anatomical) foot sizes but only those structures that are in contact with the measurement surface thereby by default underestimating true maximum foot size when under compression. Therefore it needs to be pointed out that the terms foot lengths and widths, as well as central toe lengths, as described in the 'Material' section, refer to recordings of the pressure plate only.

Goal of the study was to determine if and which gait characteristics change due to captive conditions in a pair of Indian rhinos coming from a semi-wild condition in Chitwan National Park to a European Zoo. Therefore it was assumed that only parallel changes should be taken into account. Gait parameter that remained fairly stable and did not change parallel in both animals over time were not taken into consideration, neither were parameters that only changed in the female and could clearly be attributed to her young age and the fact that she was still growing in height of the withers. These were an increase in foot-length during the first year and correspondingly an increase in footlength-to-width ratio, especially in the hind feet. It is probable however that age plays a role in to what extent parameters changed over time.

Another factor that could not be excluded in this study was the slight variation in walking speed. It could not be controlled and varied with the motivation of the animals. Whereas gait analysis in horses nowadays is usually performed on a treadmill to ensure a constant speed [14-21], this could not be done in the Indian rhinos. Many gait parameters are dependent on walking speed, not only in horses, but also in humans[9, 16, 17, 19, 22-25]. The walk is the gait with the highest variability [26], step length increases with speed [27], and swing phase duration varies [28], however stance phase duration within an individual animal seems to be very robust [24, 29]. In the present study hesitations or ambling could not be excluded and were especially present in the first data collection session in the male. Since the animal is almost blind, was not familiar with the enclosure, and was confronted with the pressure plate, his stance duration in the beginning was 1,8 seconds (front right foot) and 1,4 seconds (hind right foot) and was shortest in February of 2010 with 1,1 seconds and 0,9 seconds in the same feet. Stance duration in the female varied between1,2 and 1 seconds in the forelimb and between 1,1 and 0,9 seconds in the hindlimbs (Table 2; Table 3).

Belonging to the Perissodactyla the weight bearing digit of a rhino foot is the third digit [30], the central toe. The feet are slightly turned outward. Lateral, central and medial toe are arranged around a large soft palmar/plantar pad. The front feet are generally smaller and rounder than the hind feet, which appear more elongated [2]. Whereas the central toe is rigidly connected to the pad, both side toes remain mobile and tend to spread when the foot is set down, an essential feature when walking on soft muddy ground [2]. Both, peak contact area as well as maximum contact area, are dependent on the size of the anatomical foot and on the proportion of body mass which is supported by the foot. Generally, maximum contact area is always smaller than peak contact area (Table 2; Table 3). Especially the size of the soft part of the foot is influenced by the weight that is placed on it. Therefore if the position of the COF is more palmar/plantar, the peak and maximum contact area is higher. On the contrary, harder horn structures like the toes do not expand that much in size. Therefore if the position of the

COF is located further dorsal the peak and maximum contact areas are smaller. However, other factors influence contact area as well, abrasion of the soles is one of them. It can enlarge peak and maximum contact area if for example the concavity of the central toe decreases due to husbandry, as can be seen comparing fall and spring data collection sessions (Table 4). It can decrease peak and maximum contact area if the wear on the central toe is so strong that it changes the angle of the sole and causes a dorsal shift of the COF as is seen in both animals in Vienna (Table 2; Table 3; Figure 5; Figure 6).

In addition, peak and maximum contact areas depend on the elasticity of the pad. The elasticity of the pad is influenced by the moisture content of the keratinized tissues [31], as well as by nutrition, age and how the pad is used during locomotion. Similar factors have been described in cattle [32, 33]. Therefore contact area can also be dependent on seasonality, highly affected by summer and winter husbandry conditions due to mentioned factors. The size difference between the peak contact area and the maximum contact area provides information on how the weight bearing surfaces are being used during the stance phase. If surfaces are used only for a short time the difference is large. Therefore speed has an influence on contact area as well, as the pad sinks further into the soft rubber mat, and the foot itself splays gradually over time. This effect is described in overweight children who develop flat feet [34]. All these factors contribute to the variations of peak and maximum contact areas that can be seen over time in the two rhinos at Vienna. In addition, the female was still growing in size (Figure 2), and reaching her maximum peak contact area in the fall of 2008 (Table 3). Differences in contact area in the hind feet of the male (Table 2) were caused by the fact that in most recordings his hind left medial toe was not visible. Since this condition was constant during the entire data collection time it seems to be individual for this animal and has no impact on his health.

The position of the hard lateral, medial and central toes in relation to the soft pad determines the position of the COF to be further dorsal along the dorso-palmar/dorso-plantar axis than equally centered. In addition it has to be suspected that the position of the head and neck influences the location of the COF. In horses head and neck make up 10% of the body mass and an influence on the location of the COF has been proven [35]. Therefore the rhino walking across the pressure plate was also recorded by video camera to ensure that additional head movement was minimal.

The dorso-palmar/plantar position of the COF within the foot is strongly influenced by body mass. This could be observed during the first year of data collection (Figure 5; Figure 6). Both animals gained almost 200 kg during that time (Figure 1; Figure 2). Correspondingly the COF shifted to the mid of the footpad. An increase in bodymass also increases vertical forces. Increasing the vertical force in an equine forelimb always leads to a displacement of the digital cushion along the distal and palmar vector[36], which can act as a model for the displacement of the COF within the rhino-foot. In horses, an experimentally lowered heel, when loaded, lead to increased stress on the horn of the dorsal horn wall [37], which could also be the case in rhinos and then causing vertical cracks in the toes that can be found in 70% of all adult captive animals [1]. As soon as both rhinos lost weight the palmar/plantar shift of the COF in both front and hind feet was reversed (Figure 1; Table 2; Figure 2; Table 3). The fact that the COF was shifted even further dorsally can most likely be attributed to abrasive surfaces within the enclosure. As the horn of the sole is rasped off, the angle of the foot is altered, leading to a dorsal shift in the COF and a smaller contact area of the foot. Central toes of the hind feet are most affected by abrasive surfaces due to the function of the hind feet during locomotion. The front legs just serve as body support and absorbing the body weight and have no active participation within the motion cycle. The hind legs are responsible for locomotion due to their direct connection to the trunk and need to propulse the body mass [28]. Therefore abrasion on the central toe of the hind feet is higher than in the front feet, resulting in a more dorsal location of the COF, as is seem in the male animal (Figure 3). It is suspected that a higher body mass would increase the effect since the pressure on the abrasive surface is higher resulting in faster wear of the sole.

The central toe of an Indian rhino foot has a weight bearing dark rim of approximately 2 cm width and does not join the adjacent pad at an even level but appears 'higher'[1], thus reducing the pressure on the directly adjacent pad. According to von Houwald [2] the central toe itself is concave with a depression in the center. This could be observed in the Vienna animals especially during the first data collection periods (Table 4). After scanning through recordings of well defined toes a definition for the central concavity of the central toe was developed, defining concavity as less than 25% of force in the center of the toe compared to the rim. In addition, in the very beginning of the data collection a 'claw-shape' could be observed – a situation in which the dorsal horn rim of the central toe is longer, leaving an imprint on the pressure mat and the border of the central toe adjacent to the pad being not visible. The pictures of wild animals' feet in von Houwald's study [2], pictures of Sundari's feet from Nepal before her arrival in Vienna, and the animal's soft and muddy habitat in the wild [38] indicate that the 'claw-shape' of the central toes is the normal condition in the wild. The claw-shape would aid in propulsion on soft ground since it can prevent slipping and sliding backwards. The concave shape of the central toe that is regarded as ideal condition [1] might already be an adaption to harder ground, that also has its advantages. The sole horn as described by von Houwald [2] is softer than the weight bearing border and serves as an impact reduction, purchase increase and cleaning device of the toe. As the foot sets down it is possible that dirt and stones get caught on the sole. Through the concave shape horn structures expand when weight is placed on it and relax when relieved. This creates a pumping motion which removes small stones and dirt similar to the sole of equine hooves being pushed distally and the grooves of the frog becoming shallow during the stance phase [39].

The Indian rhinos at the Vienna Zoos revealed no clear pattern of concavity in the central toe (Table 4). It cannot be excluded, that accumulated dirt within the solar depression of the central toe could have caused a false reading in some recordings since feet were not always thoroughly cleaned before data collection. However, readings, where packed-in dirt created a reading graded as "not concave", do represent a true pressure situation at the level of the sole within the central toe, and indicate a non-functioning cleaning mechanism with potentially pathological consequences for the foot. Even though the inside enclosure in Vienna contains a thick rubber layer concavity in the central toes of the hind feet cannot be seen anymore in either animal after the first data collection period (Table 4). The top coat of the rubber layer contains an overspray of 1mm with small hard rubber particles to prevent slipping when the surface is wet. This top coat acts like a rasp when the animals slide their feet across the surface. Since there is still more concavity observed in the front feet than in the hind, the sliding motion seems to be carried out more in hind feet than in front.

An additional factor influencing the longitudinal position of the COF is the length of the central toe, especially in the hind foot. Toe length in this study corresponds to 'depth of sole' in von Houwald's study [2]. The length of the central toe was only measured in readings in which the weight bearing rim of the central toe was clearly discernable. If the hind central toe gets exceedingly long the COF shifts dorsally due to forces that increase at push-off [40]. Outgrowth of the central toe was observed in the 5 year old female at Vienna Zoo (Sundari, fall of 2008). She was still considered a calf at her arrival in 2006 and within her first year at the Vienna Zoo her right hind central toe grew 0,8 cm, her left hind toe 0,6 cm (Table 3), which could be attributed to general body growth, since she also grew 13 cm at the height of the withers (Figure 2). In fall of 2008 her hind central toe had increased by more than 1 cm compared to the previous year and increasing even more to over 7cm until March of 2009 with little additional body growth. A similar growth of the hind central toe was seen in the young adult male Jange. He did not grow in size during his first year in Vienna, neither did his hind central toe. In fall of 2008 however his hind left central toe had also increased by about 1 cm compared to the previous year. The reason for a lower increase in the hind right central toe (Table 2) can be due to an increased wear if generally the right side is the preferred one of the animal. However, over time horn growth and wear were more equal in the male than in the female.

From March 2009 until February of 2010 the length of the hind central toes took in more than 28% of the entire foot length (Table 3) compared to a maximum of 25,7% in the male (Table 2). The relatively long toe is more stable than a smaller toe and it transfers more weight. This effect is seen in cattle, where the claw sizes of the medial and lateral claws correspond with the loading pattern of the limb and its conformation, and the larger claw developing on the side that carries more weight [41]. The disadvantage of a long central toe, or more accurately a long sloping dorsal wall of the central toe is the fact that during gait Indian rhinos break over the central toe creating shear forces between the palmar/plantar rim of the central toe and the adjacent pad, in the 'area of minor resistance' as this was called by von Houwald [2], leading to cracks and over time to foot problems. In dairy cattle it is known that the hind limbs during pushing off have to withstand pressures of 180 – 200 N/cm^2 and that these pressures pose a major threat to overloading softer parts of the hind claw, which are the sole or the bulb area [40]. Increased shear forces due to the outgrown hind central toes have already caused minor cracks on the anterior part of the footpads in both hind feet of the female, especially during the winter of 2009/2010 and 2010/2011. Due to season moisture content and therefore also the elasticity of the pad was low. Regular treatment with Neutrogena hand cream already proved successful (keeper information).

The reason for the outgrowth of the toe and the dorsal shift of the COF being more severe in the female is unclear but could be due to different activity [3], to age or might be individual. Genetic predisposition, neonate nutrition, hormonal differences as well as overall body structure and conformation might be factors that need to be taken into account. Generally hoof growth is affected by several factors in the equine foot. These are age, genetics, metabolic rate, exercise, external temperature, environmental moisture, illness and trimming, but also strongly affected by nutrition influences such as energy intake, protein and amino acid intake, minerals such as zinc and calcium, and vitamins such as biotin and vitamin A [42]. Which factor(s) had an influence on the outgrowth of the hind central toes in the female wear remains open.

Both animals share the same habitat, the same keeper routine and nutrition. Therefore it can be concluded that captive conditions at Vienna Zoo did cause a change in the foot anatomy of the two Indian rhinos coming from Chitwan National Park, Nepal. Especially the abrasive surfaces, most likely the top-coat on the rubber-flooring in the inside enclosure caused a dorsal shift of the COF to the anterior part of the footpad, an area of minor resistance and high shear forces, the area in which Chronic Foot Disease usually starts to occur. In addition, remnants of a claw-shaped central toe disappeared soon and concavity of the central toes was largely reduced. An elongated hind central toe, as is seen in the female, even increased shear forces and the risk of CFD to develop. The results of this study support husbandry recommendations of Indian Rhinos[1] and suggest that abrasive surfaces cause more foot problems on animals with normal weight than overfeeding would cause in animals living on deep, soft ground.

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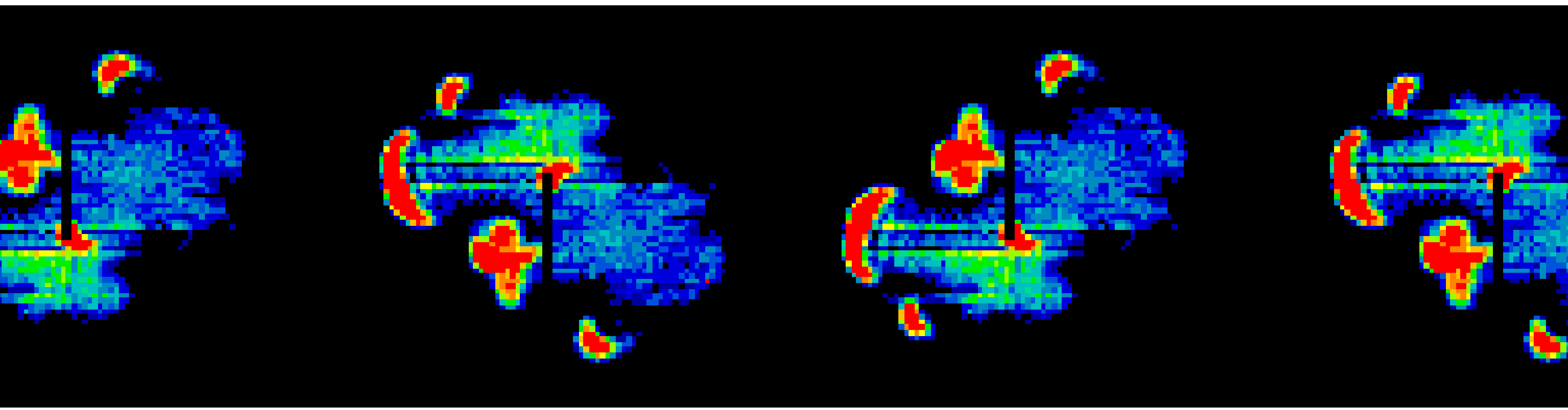
Zoo Vienna

From Chitwan to Vienna.

How do gait parameters change in a pair of Indian Rhinos (*Rhinoceros unicornis*) coming from semi-wild conditions to a European Zoo?



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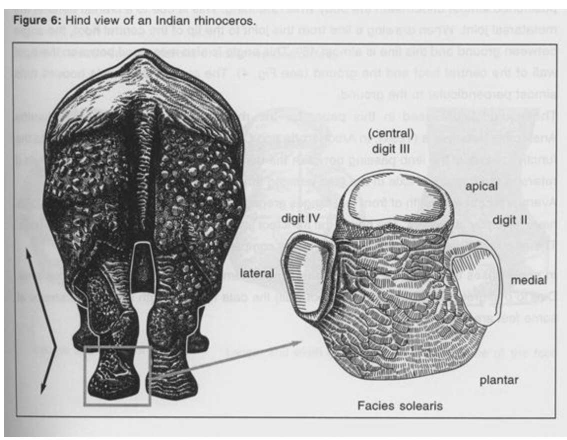
Why look at gait parameters in Indian Rhinos?

- Deviations from a certain gait pattern can exhibit clinical problems, even before severe signs of pain are exhibited in horses.
- Therefore attention has been given to the use of gait analysis as a clinical tool. [1]

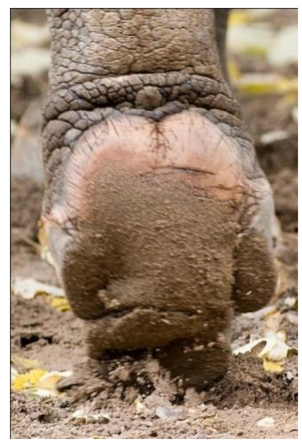
[1] Peham, 1999

Why look at gait parameters in Indian Rhinos?

- 25% of all Indian Rhinos in zoological institutions of US and Europe show chronic infection of cracks between pad and central toe (=Chronic Foot disease, CFD)
- Hind feet are more commonly affected
- Males are more commonly affected
- Can already occur at the age of 5 years, but most commonly starts between 7 and 11 years. [1]



Von Houwald 2001



Thorough kinetic gait analysis can be the key to understand characteristics of the Indian rhino’s gait and in due course can continue the understanding of early detection and treatment of CFD.

[1] Von Houwald 2001

Why look at gait parameters in Indian Rhinos?

Friederike von Houwald (2001): Foot problems in Indian Rhinoceroses (Rhinoceros unicornis) in zoological gradens: Macroscopic and microscopic anatomy, pathology and evaluation of causes

- Indian Rhinos are sole-walkers, meaning that they use sole and weight bearing border of their digits for bearing weight.
- Captive conditions (abrasive materials for indoor enclosures, overfeeding) have lead to a change in the foot anatomy and turned them into a pad-walker with a weight shift palmar/plantar to the mid part of the footpad.

- Monitor the development of gait parameters of a pair of Indian Rhinos from semi-wild conditions (Rhino Orphanage, Chitwan National Park, Nepal) coming to a zoological institution (Vienna Zoo, Austria).

Zoo Vienna

BELAGSAUFBAU

Overspray ca. 1mm

Flüssigfoliensystem wie vor um eine rutschhemmende Oberfläche zu erreichen

Oberflächenschutzmembran 4mm

- 2 - Komponenten Flüssigfoliensystem auf Polyurea – Flüssigharzbasis
- lösemittelfrei
- flüssigkeitsdicht
- nahtlos
- abriebfest
- risseüberbrückend

Kunststoffbelag Stärke 20mm, bestehend aus:

- Gummigranulat mit PU-Bindemittel - schwarz
- UV – beständig
- Körnung 1 - 4 mm
- gelenksschonend

Data collection

Male Jange, born 1997

Female Sundari, born 2003

Female: calf (age 0-4) | Subadult (age 4-6) | Young adult (age 6-12)

Male: Young adult (age 6-12) | Intermediate age (age 12-24)

Continuous weekly to biweekly data collection

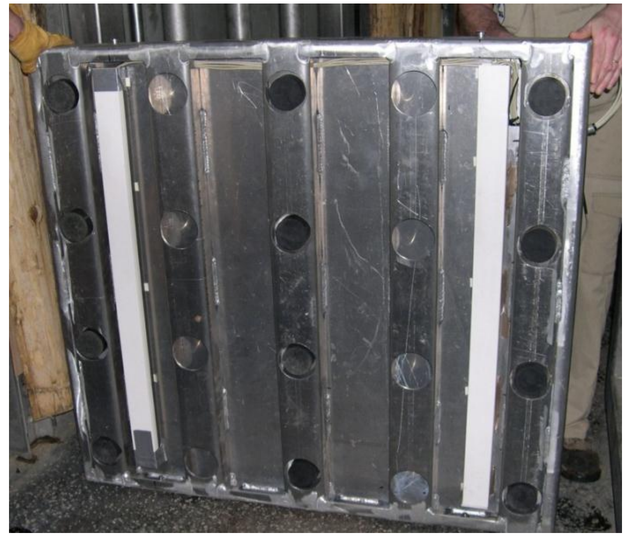
- March 2006 Arrival in Vienna
- June 2006
- June 2007
- Aug./Sept. 2008
- March 2009
- Sept. 2009
- Feb. 2010
- Sept. 2010
- March 2011

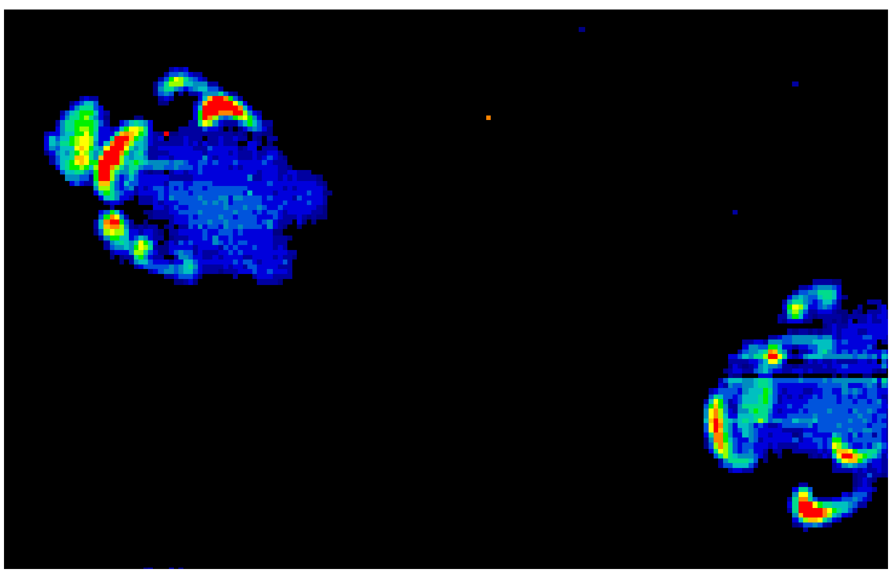
Age categories according to Dinerstein 2003

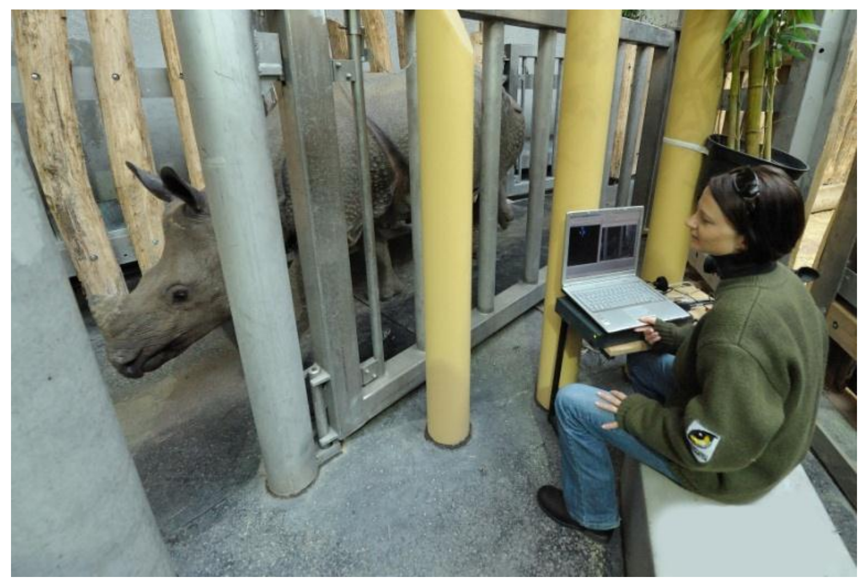
Zoo Vienna

Method

Tekscan Walkway 4
• 90 cm x 100 cm measuring area
•4 sensors per sqcm
• 39 Hz measuring frequency







Zoo Vienna

- 54 days of data collection
- 626 valid data sets

Sample size of each foot of the animals in Vienna throughout data collection period

	Front right foot	Front left foot	Hind right foot	Hind left foot
Sundari				
June 2006– June 2007	64	68	59	64
Aug./Sept. 08	9	7	7	9
March 09	12	15	12	14
Sept. 09	13	13	15	11
Feb. 2010	12	13	11	11
Sept. 2010	14	9	14	10
March 2011	13	10	13	10
Jange				
June 2006– June 2007	62	68	59	64
Aug./Sept. 08	8	6	7	5
March 09	14	10	14	10
Sept. 09	11	13	12	11
Feb. 2010	17	12	15	10
Sept. 2010	10	14	10	14
March 2011	9	8	9	9

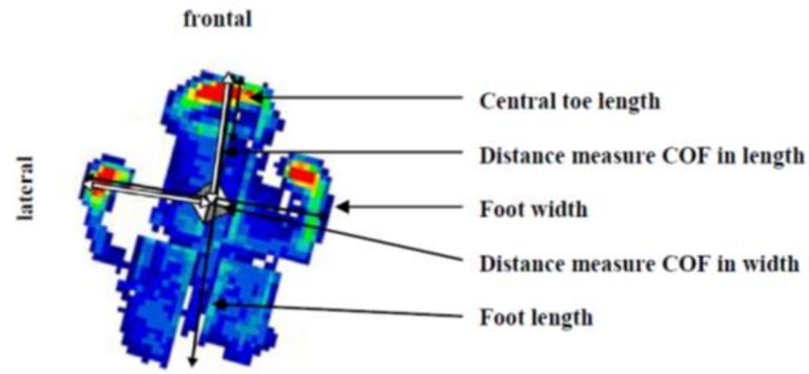
23 Parameters collected, including:

- Gait duration (s)
- Stance duration (s)

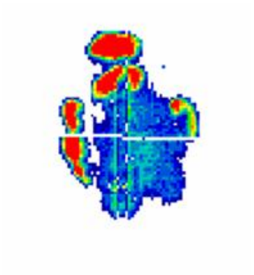
- Overall Force (N)
- Maximum Force (N)

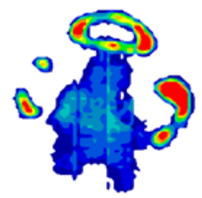
- Foot length and width (cm)
- Length of central toe (cm)
- Peak contact area (cm^2)
- Maximum contact area (cm^2)

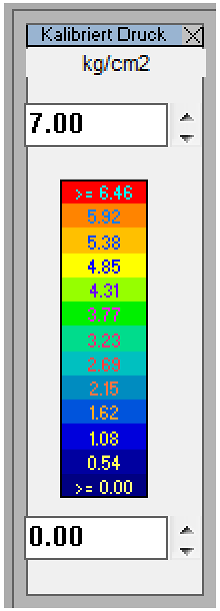
- Front and hind foot overlap
- Central toe concavity



- Center of Force – COF (%)
- COF trajectory

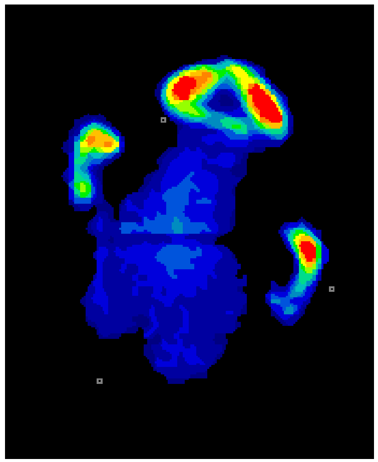


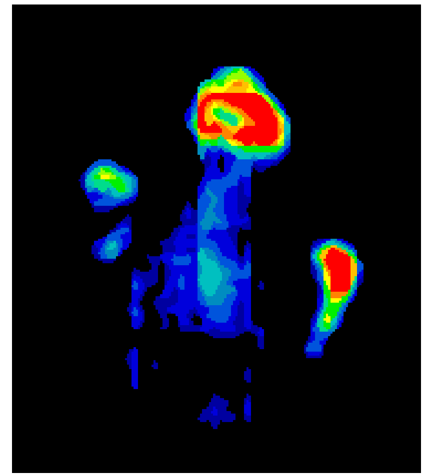




Peak contact area (cm^2): largest contact area over all contact frames of one footprint

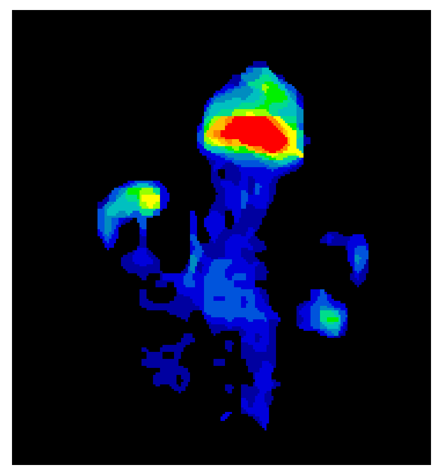
Male Jange
hind right foot
June 2006



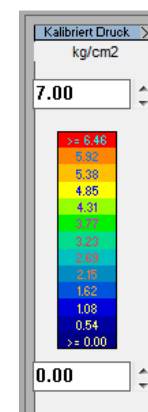


Male Jange
hind right foot
September 2010

Female Sundari
hind right foot
June 2006



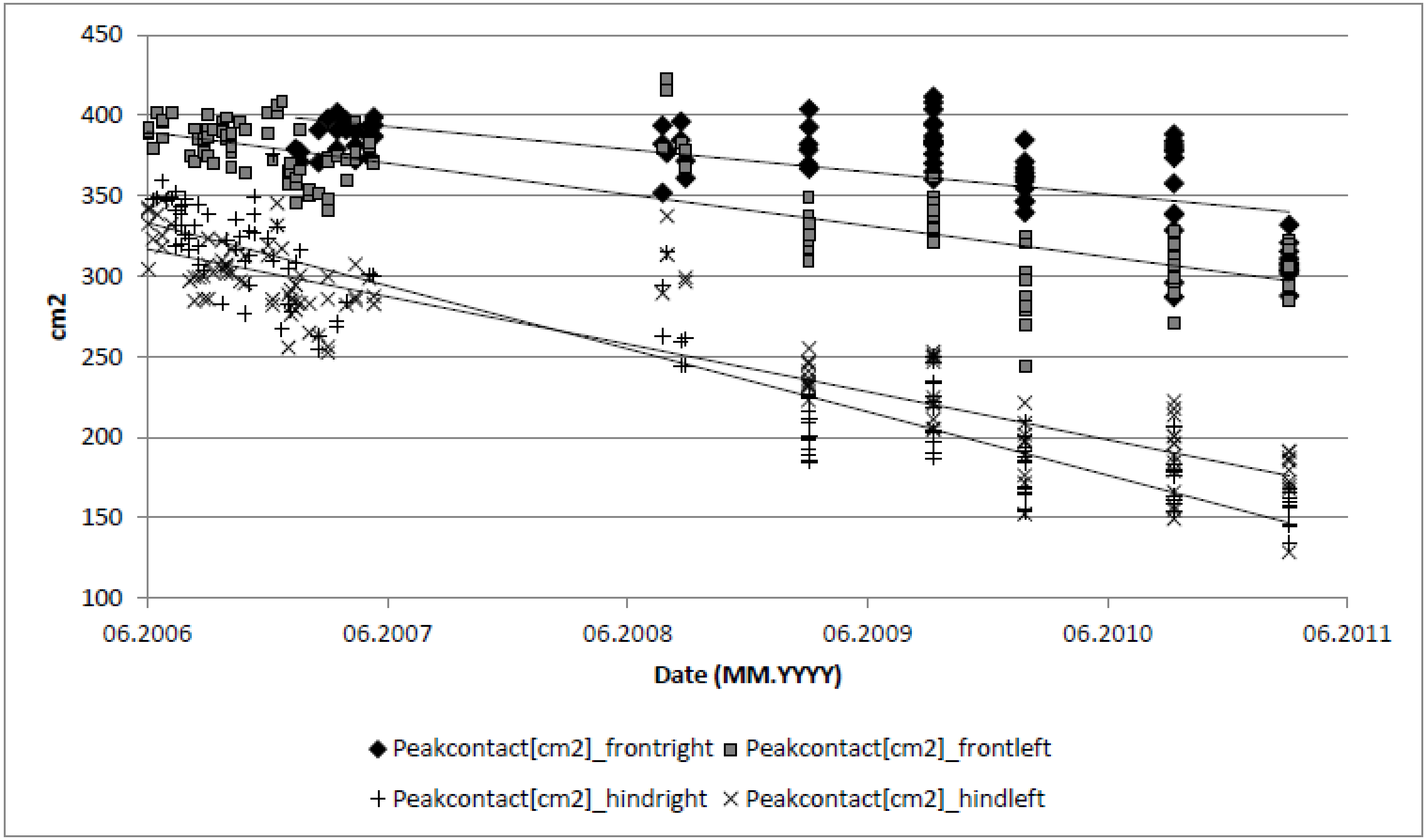
Female Sundari
hind right foot
September 2010



Zoo Vienna

Peak contact area (cm^2): largest contact area over all contact frames of one footprint

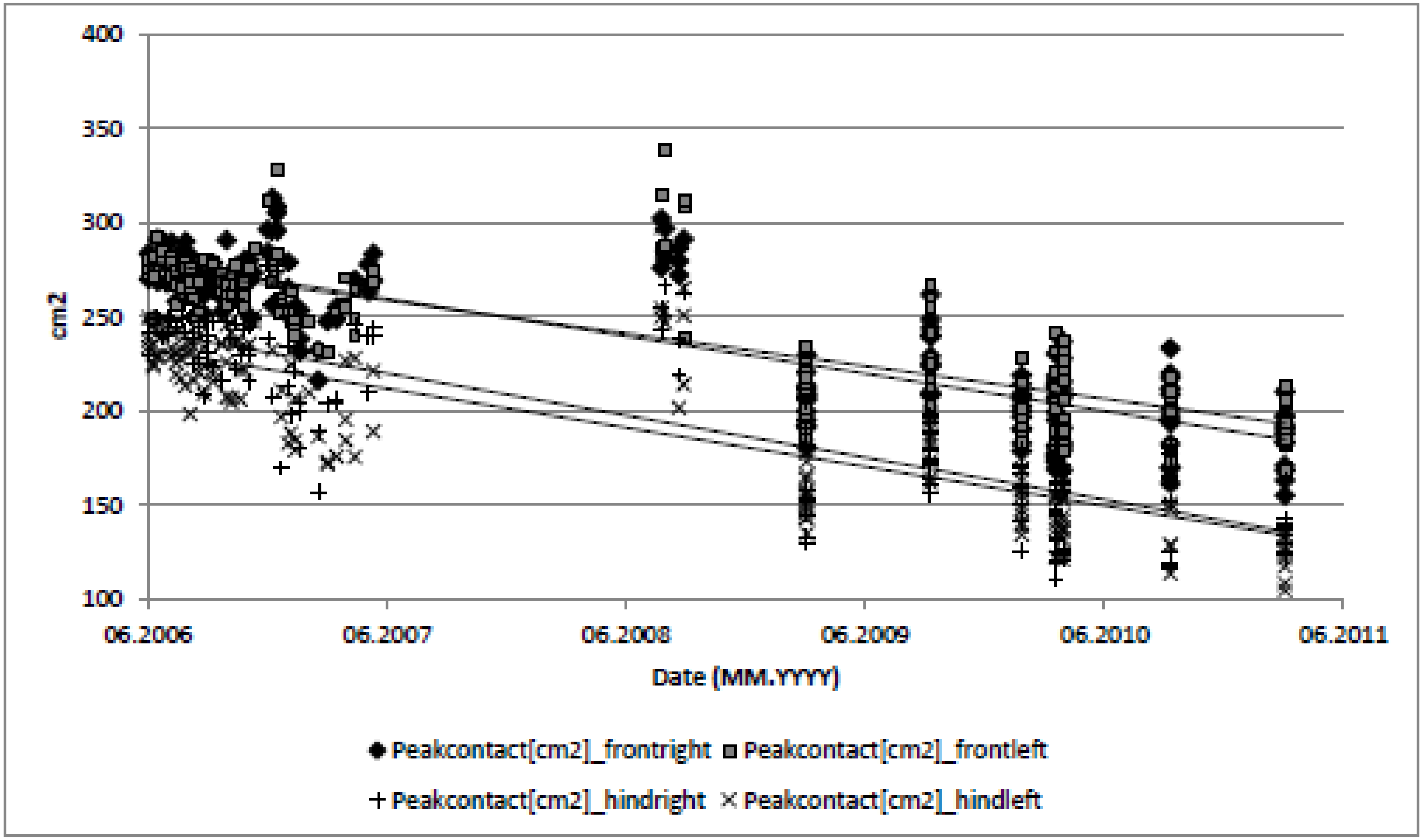
Male Jange



Zoo Vienna

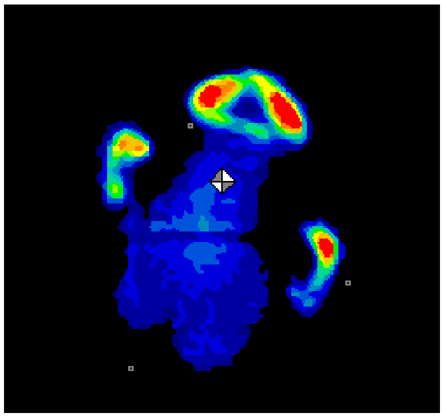
Peak contact area (cm^2): largest contact area over all contact frames of one footprint

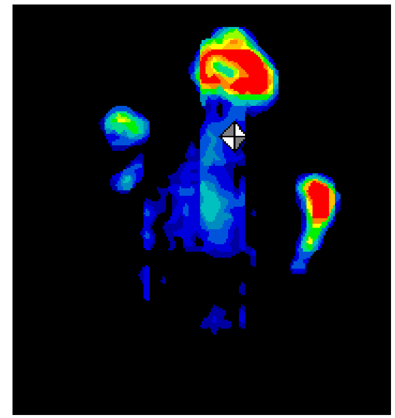
Female Sundari



Dorso-palmar/plantar shift of Center of Force COF (%): shows the center of all the forces on the sensor.

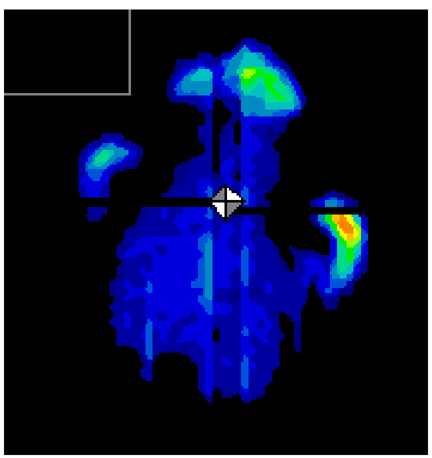
Male Jange
hind right foot
June 2006

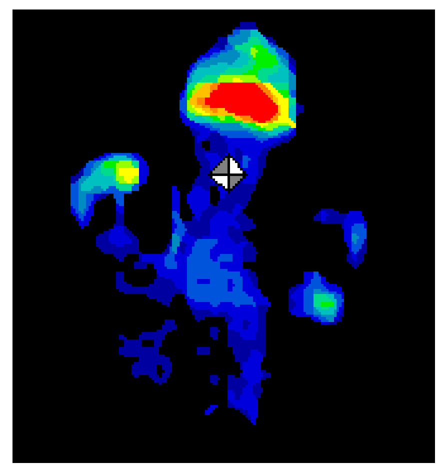




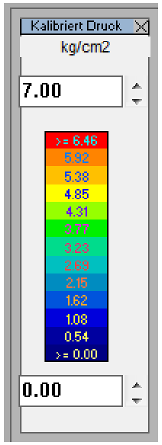
Male: Jange
hind right foot
September 2010

Female Sundari
hind right foot
June 2006



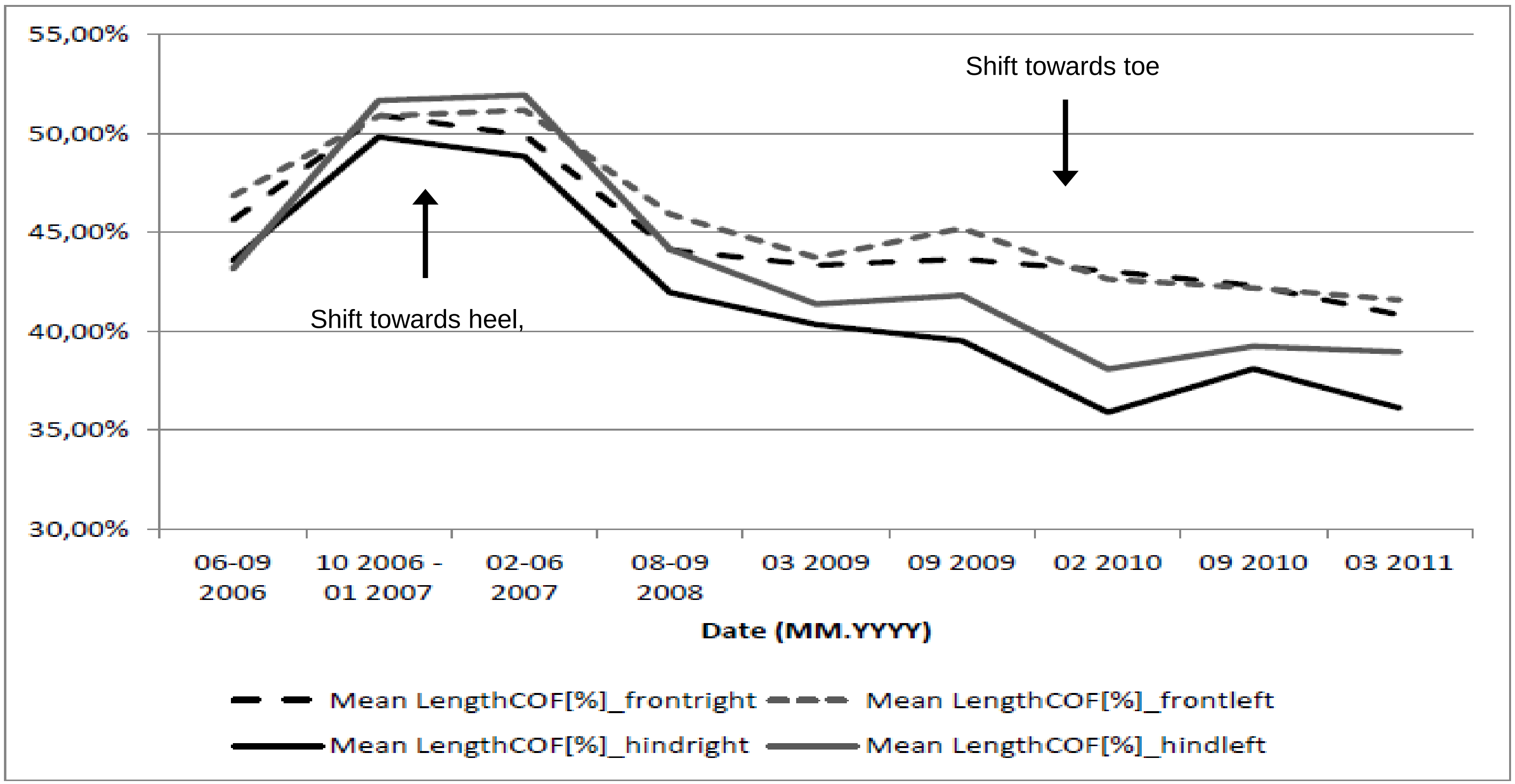


Female Sundari
hind right foot
September 2010



Dorso-palmar/plantar shift of Center of Force COF (%): the location of the COF was measured in centimeters in a parallel line to maximum foot length, starting dorsally and calculated as percentage of the entire foot length

Male Jange



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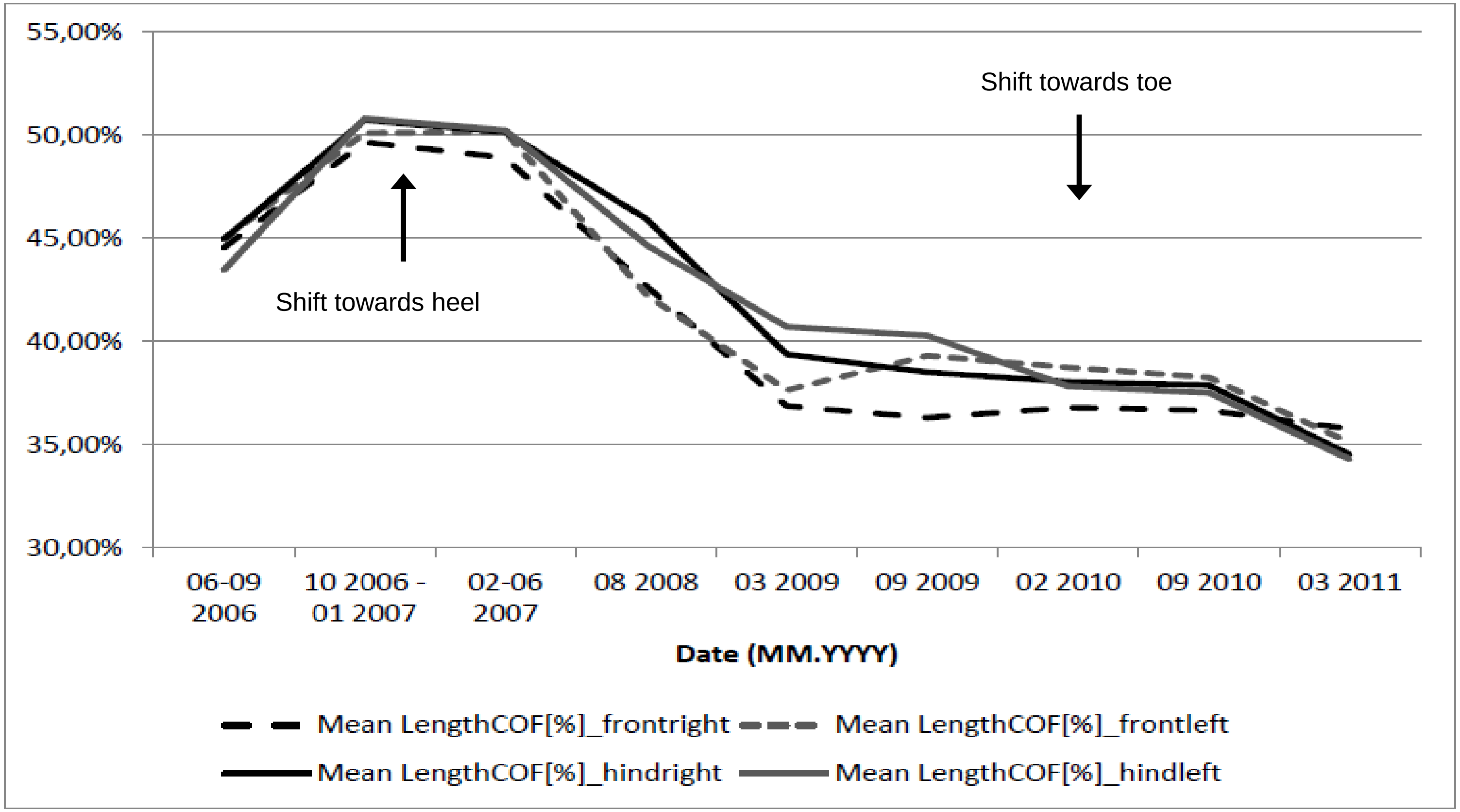
Dorso-palmar/plantar shift of Center of Force COF (%): the location of the COF was measured in centimeters in a parallel line to maximum foot length, starting dorsally and calculated as percentage of the entire foot length

Female Sundari



Why does the COF shift towards the heel in the first year?

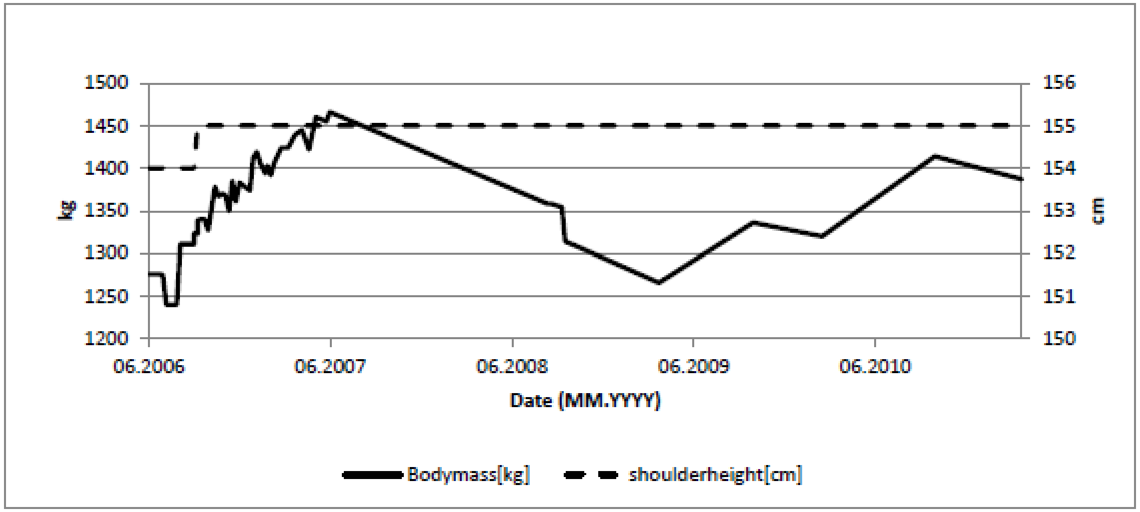
COF shift ⟶

⟵ COF shift

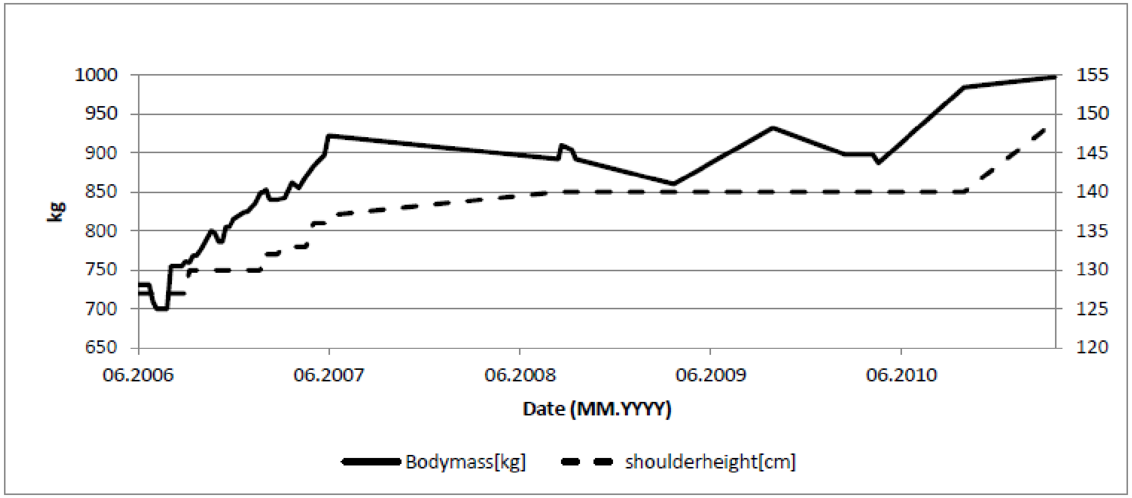
Sole abrasion

- Caudal shift due to increase in bodymass
- Dorsal shift due to sole abrasion of the central toe

Male Jange



Female Sundari

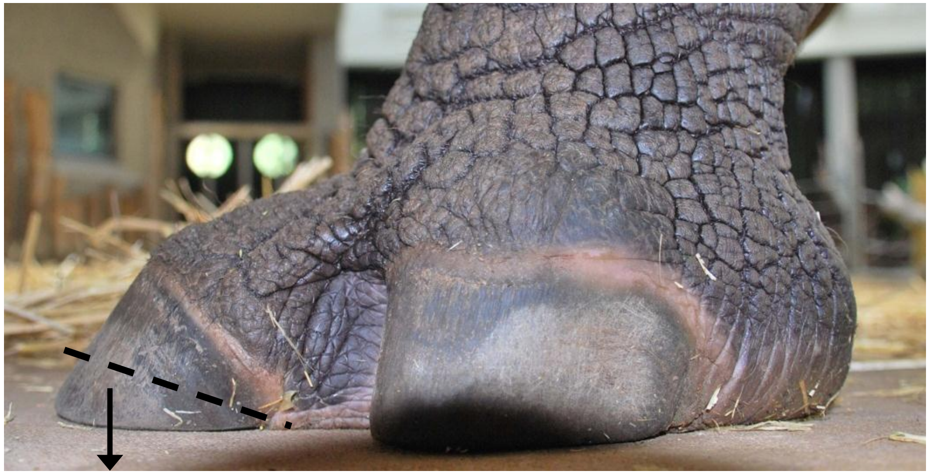


Why does the COF shift towards the toe later on?

COF shift ⟶

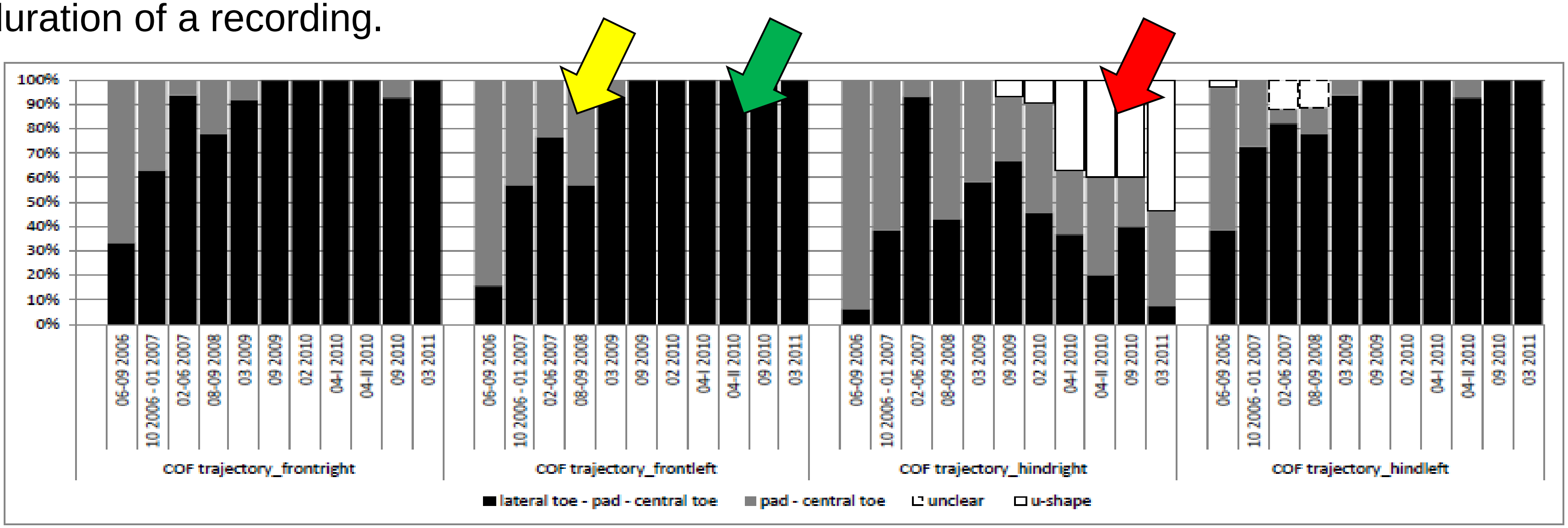
⟵ COF shift

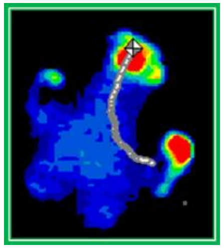
- Caudal shift due to increase in bodymass
- Dorsal shift due to sole abrasion of the central toe

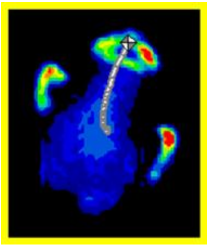


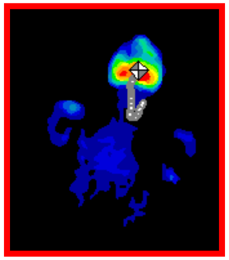
Sole abrasion

COF trajectory: The COF trajectory displays the movement of the center of force for the duration of a recording.





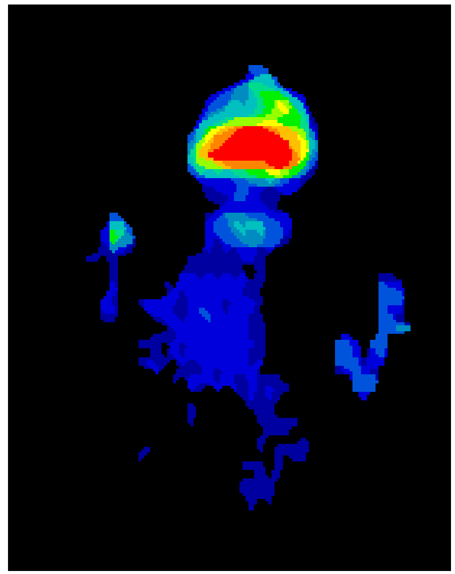


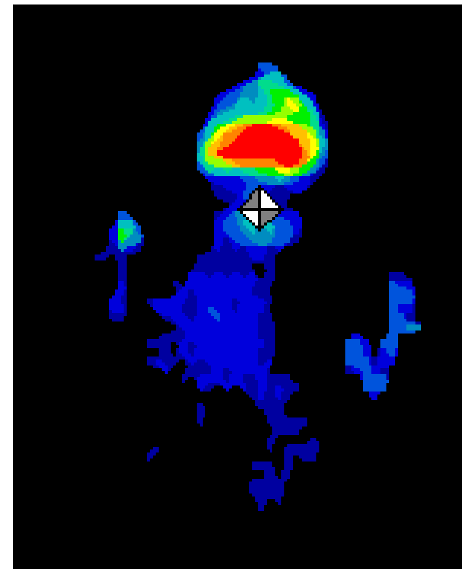


- April I: data collection
- Administration of 3-day therapy with an NSAID (2x 1,5g/day Phenylbutazon)
- April II: data collection

- No change in COF trajectory
- No signs of lameness: Stance duration and Overall or Maximum Force did not differ between left and right

Sundari August 2011, hind right

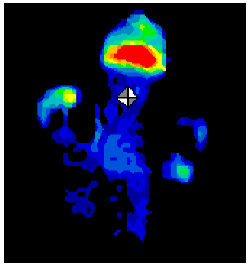




Sundari hind right, March 2011

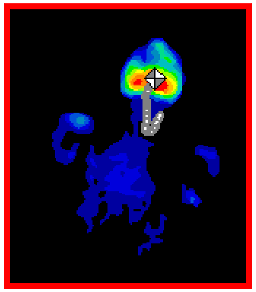
A persistant change in the COF trajectory of one foot might be a early sign of the development of CFD before the animal exhibits any sign of pain and before a problem is visible to the human eye.

Summary:
The Vienna Rhinos

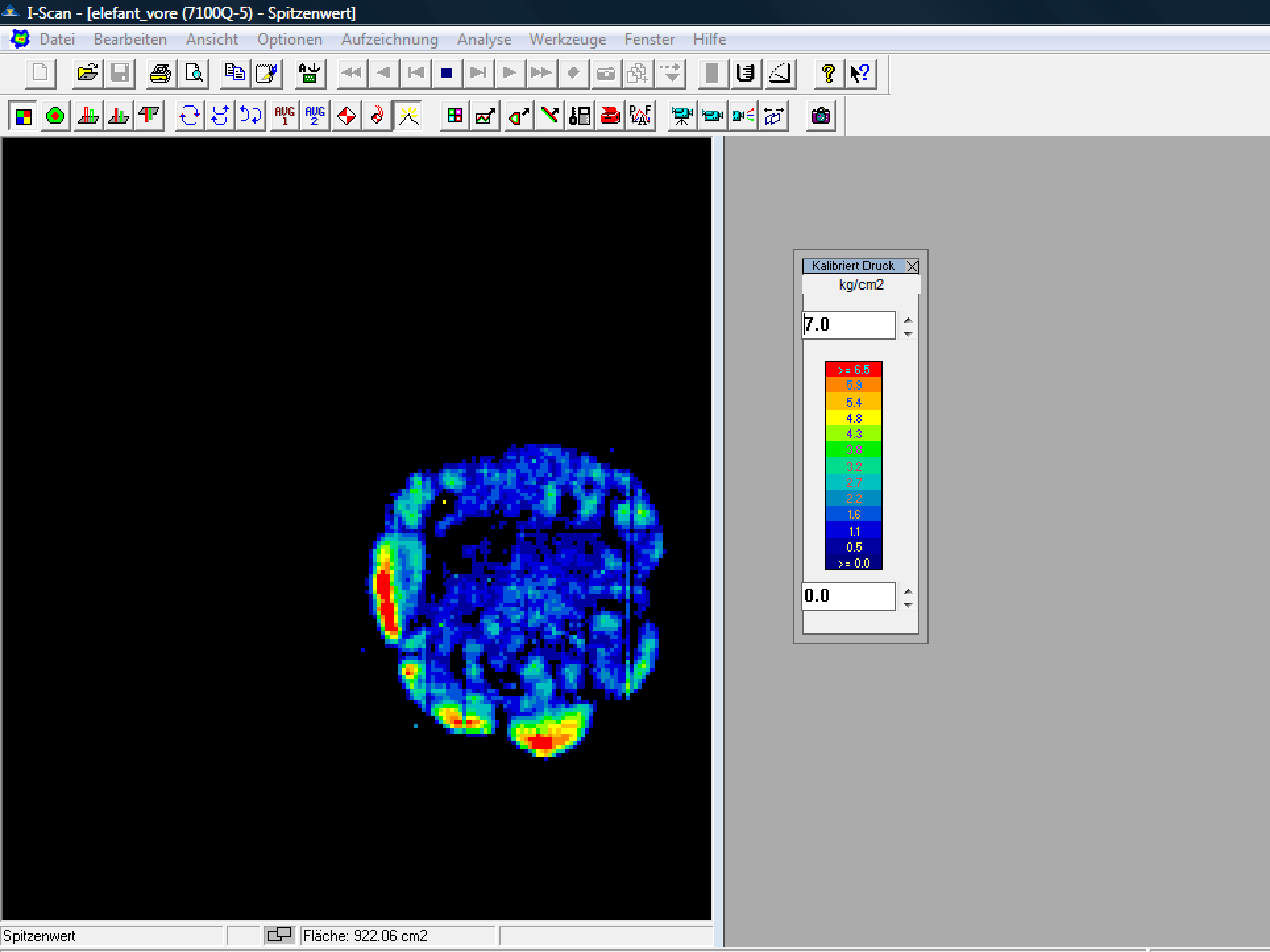


- Exhibited dynamic data, influenced by many factors

- A caudal shift of the COF due to increase in body mass
- A dorsal shift of COF due to increased sole abrasion at central toe



- A persistant change in the COF trajectory of one foot might be a early sign of the development of CFD before the animal exhibits any sign of pain and before a problem is visible to the human eye.
- Kinetic gait analysis could be an easy, non-invasive objective tool to detect early stages of chronic foot disease


I-Scan - [elefant_vore (7100Q-5) - Spitzenwert]
Datei
Bearbeiten
Ansicht
Optionen
Aufzeichnung
Analyse
Werkzeuge
Fenster
Hilfe
Kalibriert Druck
kg/cm2
7.0
>= 6.5
5.9
5.4
4.8
4.3
3.8
3.2
2.7
2.2
1.6
1.1
0.5
>= 0.0
0.0
Spitzenwert
Fläche: 922.06 cm2

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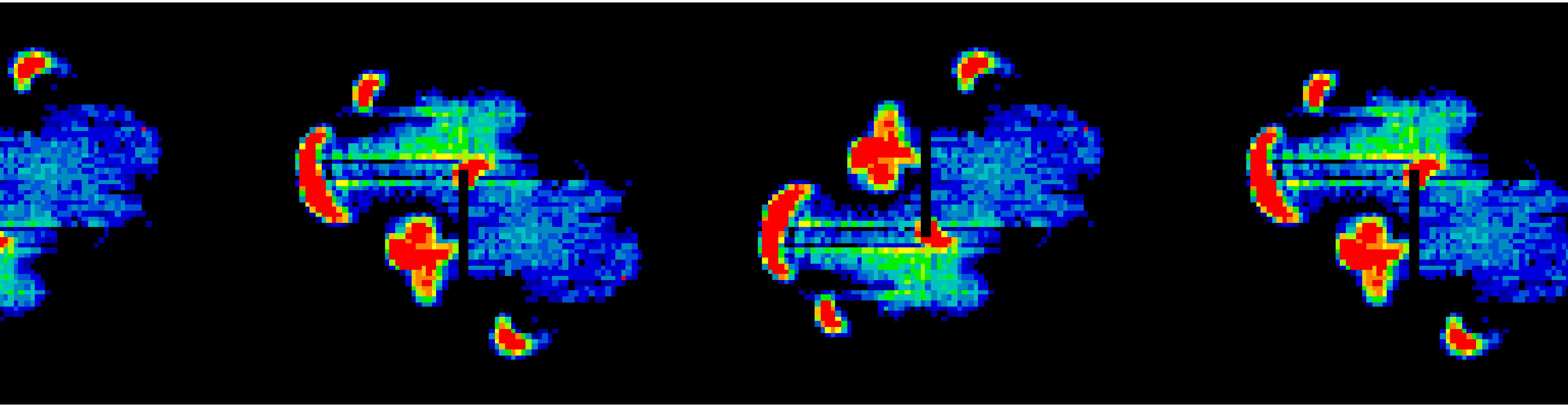

ÖNB
Oesterreichische Nationalbank
Projectnumber: 11902

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Movement Science Group Vienna

Acknowledgements

- Vienna Zoo Staff members, especially Rhino keepers and director Dagmar Schratter
- Felix Knauer from the Research Instiute of Wildlife Ecology for statistical advic
- Albi Schneider, Savecomp Megascan for technical advice