Archivos de Zootecnia
Journal website: https://www.uco.es/ucopress/az/index.php/az/

Biokinematics and applied thermography in the Canarian camel breed

Iglesias, C.[1]; Navas, F.J.[1]; Ciani, E.[2]; Arando, A.[1]; González, A.[1]; Marín, C.[1]; Nogales, S.[1] and Delgado, J.V.[1]

[1]Departmento of Genetics. Faculty of Veterinary Sciences. University of Córdoba. Córdoba. Spain.
[2]Departament of Biosciences, Biotechnologies and Biopharmaceutics. Faculty of Veterinary Sciences. University of Bari "Aldo Moro". Bari. Italy..

ADDITIONAL KEYWORDS

Canarian camel breed.
Camelus dromedarius.
Biomechanics.
Thermography.
Cortisol.

SUMMARY

Anatomical and locomotive understanding of natural gaits in camels is an essential tool for its kinetic and kinematic evaluation as they constitute elements of marked predictability for functional performance, energy expenditure and training response. Biomechanics evaluation, complemented with applied thermography analysis, makes possible the precise delimitation for those risk factors potentially associated with musculoskeletal injuries derived from the physical work these animals do, mainly classified as multifactorial etiology pathologies. Speed competitions, recreational exhibitions or tourist walks are some of the motor activities carried out by camels, being outlined by strong cultural roots in specific geographical regions. In particular, Canarian camel breed *(Camelus dromedarius)* is marginally relegated for touristic activities. As an autochthonous endangered breed, the systematized adjustment of locomotor performance records will enrich the viability and sustainability of its conservation programmes, selective breeding and functional revaluation actions.

Análisis biocinemático de locomoción y termografía aplicada en la raza camellar canaria

PALABRAS CLAVE ADICIONALES

Camello canario.
Camelus dromedarius.
Biomecánica.
Termografía.
Cortisol.

RESUMEN

La comprensión anatómica y locomotora de los aires naturales del camello es un elemento esencial para su evaluación cinética y cinemática en tanto que constituyen herramientas de marcada predictibilidad del rendimiento funcional, gasto energético y respuesta al entrenamiento. El estudio biomecánico, en asociación con evaluaciones termográficas complementarias, permite la delimitación precisa de los factores de riesgo potencialmente asociados a lesiones músculo-esqueléticas derivadas del trabajo físico desarrollado por estos animales y en consideración de patologías de etiología multifactorial en la mayor parte de los casos. Competiciones de velocidad, exhibiciones lúdicas o paseos turísticos son algunas de las actividades motoras desempeñadas por camellos y que, en regiones geográficas concretas, se encuentran perfiladas por un marcado arraigo cultural. En el caso particular del camello canario *(Camelus dromedarius)*, su uso actual está marginalmente relegado al sector turístico. En condición de raza autóctona amenazada, el ajuste sistematizado de registros de rendimiento locomotor enriquecerá la viabilidad y sostenibilidad de las acciones de conservación, cría selectiva y revalorización funcional de esta raza camellar.

INFORMATION

Cronología del artículo.
Recibido/Received: 04.07.2019
Aceptado/Accepted: 28.12.2019
On-line: 15.01.2020
Correspondencia a los autores/Contact e-mail:
fjng87@hotmail.com

INTRODUCTION

The camel is a digitized artiodactyl, that is, its limbs are supported exclusively, both at rest and during locomotion, on its only two fingers. Among its many adaptations to life in arid areas and dune fields, the fingerprint or impression produced by the contact of its fingers on the sand of these lands, is comparatively superior to that of other species of ungulates. This characteristic is reflected on an homogeneous distribution of finger pressure points on a larger support surface, thus achieving a light impression on the soft sand of the dunes, preventing their excessive sinking and speeding up their locomotion. The length of its legs and the conformation of its junction musculature also allow amplitude in the articular movement of the axis of its limbs (Dagg 1974; Dagg & Vos 1968), without interference between fore and rear legs. They support the posterior limb first, facilitating its propulsion as well as cushioning the impact (Kar, Isaac & Jayarajan 2003).

The habitual march of a species is a characteristic closely related to its morphology, energy balance and behavior, which would enable the interpretation of any alteration in these with a binding nature to the whole (de la Fuente Fernández 2019). The way in which they move in their different marches and the cadence of the movements that in each one of them execute, allows distinguishing three basic forms of movement in camels: slow step, fast step and galloping. Slow step and fast step are the usual movement modalities in these animals, travelling long distances looking for food without too much energy expenditure (Howell 1944; Janis et al. 2002; Webb 1972). They rarely gallop so as to avoid excessive sweating and, consequently, saving water, except for situations that may entail potential risks to their survival, interactions between young individuals or during racing competitions (Dagg 1974).

In this regard, the biomechanical functional assessment aims to delimit and define the natural phenomena that occur in a living organism as a result of the application and/or concatenation of forces of diverse origin to move. For the achievement of this integrated evaluation, the purely mechanical and kinematic phenomena of the movement are considered, as well as the physiological processes and their pathological variations that take place during the execution of this.

The mechanical (elasticity and resistance) and structural properties of the osteoarticular and muscular systems of each animal species reveal multiple adaptations and specific functionalities that have contributed to the conformation of its musculoskeletal system (Currey 2014). Based on biomechanical studies, there is a consensus about the biological relevance of the thickness of the periosteum of the long bones of the limbs in mammals, a characteristic that gives them optimal mechanical properties that allow the desired acceleration and deceleration in each cadence of movements (Alexander 1996; Bernáth et al. 2004; Currey 1982). Closely related to this condition, the careful examination of recent footprints along a trail would enable early detection of musculoskeletal pathologies if the stride length is shorter than expected under normal conditions (de la Fuente Fernández 2019).

The examination of the physical actions performed by living organisms, from their origin to their effects, also pursues the objective measurement of their performance according to the optimization of the energy expenditure associated with this physical work (Alexander 2003; Maloiy, Rugangazi & Rowe 2009). The anatomical conformation and overall functioning of the muscle-tendon binomial could play a substantial role in saving energy or its efficient use during locomotion (Alexander et al. 1982; Butcher et al. 2009). The design of correlational biomechanical models (metabolic rate, speed, body mass, physiological constants and their alterations) constitutes an essential objective assessment tool in this scientific discipline (Alexander, Jayes & Ker 1980; Blanco & Gambini 2006).

As an analytical complement of notable added value, infrared thermography systems makes possible to obtain regional surface temperature mappings in a fast, simple and precise way (Abdoun et al. 2012). This non-invasive technique aims to monitoring physiological functions through its reflection in variations in surface temperature as well as the diagnosis, detection and prevention in early stages of lesions or pain points and their therapeutic follow-up (Eddy, van Hoogmoed & Snyder 2001; Mazur, Herbut & Walczak 2006).

The objective of this project is the biomechanical characterization of the Canarian camel breed (*Camelus dromedarius*) by assessing those kinetic characters directly involved in a better performance of the functional activities currently performed by these animals, as well as other possible activities of economic interest and potential viability in this camel breed.

MATERIAL AND METHODS

Kinetics evaluation

The biocinematic evaluation is carried out by recording high-speed photographs during the execution of the movement on a flat surface and subsequent data processing, curves design and establishment of mathematical models for analysis and interpretation. These recorded images are calibrated according to the coordinate scale from these pictures and the test data are leveled by three smoothing methods applied by the Kinovea software, used for the kinematic evaluation of the animals.

The animals are recorded, at least, from two different views (a side view and a front view) and the duration of each recording is that necessary for the animal to complete the circuit in each of the three gaits evaluated (slow step, fast step and galloping). The cameras are located in strategic locations of the emplacement so as to record the experiences without interfering with the movement of the animal along the evaluation track. Prior to the recording, the length of the body and the height of the camel are assessed and reflective markings arranged at specific points of the animal to be measured. If proper handling of the animals for kinetic evaluation could involve some difficulties or risk for the people in charge of their guided driving, the fast step and galloping could be filmed while the animals are free-ranging (Khan, Arshad & Riaz 2003).

The process of movement and the differential contribution of the anterior and posterior legs are evaluated. The interaction between the foot of the camel and the sand is also assessed with the same software from digital photographs of the tracks of the camel on the ground (Alexander et al. 1982) (**Figure 1**).

The variables considered for the biocinematic evaluation of the camels are speed, acceleration, linear and angular displacement, inclination angles, range of mobility of the different joints of the limbs, length of the stride, duration of the cycle, load factor of the limb (ratio of the time it takes for the animal to complete the one-step action cycle within the set comprised by the gait cycle) and footprint position (distribution and support time of foot) (Dagg, 1974; Zhihao & Peijun 1993).

Movement parameters obtained after smoothing consecutive times are adjusted to a trig function as a combination of the following anatomical regions (**Figu-**

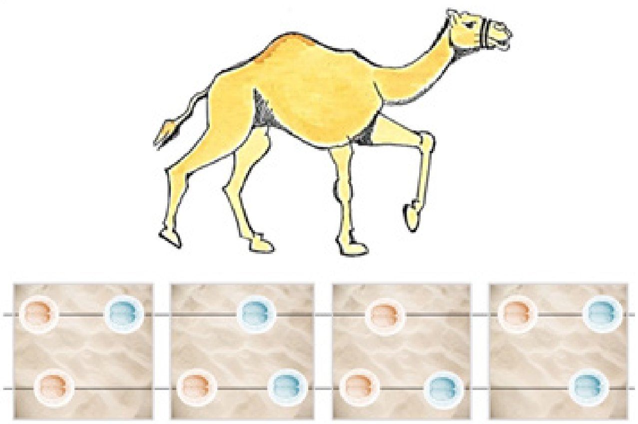

Figure 1a. Graphical representation of the pattern of footprints on the ground during the slow step in camels. Blue: forelimbs; orange: rearlimbs (Representación gráfica del patrón de huellas en el suelo durante el paso lento en camellos. Azul: extremidades delanteras; naranja: extremidades traseras).

Figure 1b. Graphical representation of the pattern of footprints on the ground during the fast step in camels. Blue: forelimbs; orange: rearlimbs (Representación gráfica del patrón de huellas en el suelo durante el paso rápido en camellos. Azul: extremidades delanteras; naranja: extremidades traseras).

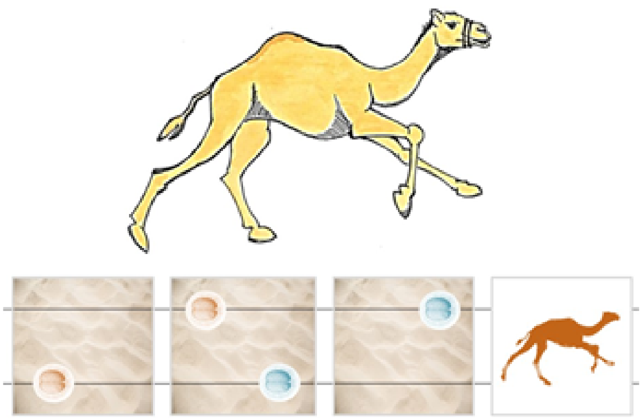

Figure 1c. Graphical representation of the pattern of footprints on the ground during galloping on camels. Blue: forelimbs; orange: rearlimbs (Representación gráfica del patrón de huellas en el suelo durante el galope en camellos. Azul: extremidades delanteras; naranja: extremidades traseras).

re 2): cranial angle of the scapula, shoulder joint, elbow joint, carpal region and metacarpal-phalangeal joint in the forelimbs; iliac crest, coxofemoral joint, knee joint, tarsal region and metatarsal-phalangeal joint in the hind limbs.

Additionally, the individual locomotion process is evaluated according to the qualitative scale described in **Table I** (Sprecher, Hostetler & Kaneene 1997). The assigned score is mostly related to the position of the dorsal axis during movement.

Thermographic evaluation

The thermographic examination should be carried out avoiding direct sunlight. Simultaneously, every half hour, all the direct climatic factors that could be involved, such as temperature, relative humidity and air direction are recorded (Autio et al. 2006). These values must be considered for the calibration of the thermal imager before proceeding with the evaluation of the animals.

The thermal imaging equipment is high resolution. The long-wavelength IR (LWIR) band covers approximately 8-14 µm, with almost 100% transmission in the 9-12 µm band. The LWIR band offers excellent visibility of most terrestrial objects with a spectrum of -20ºC to 300ºC. The camera has a field of view of 27º at 35º/0.5m and can distinguish a temperature difference of 0.07ºC. The general views are taken from both sides of the camel at an approximate distance of 2 m. For a thorough examination of more localized areas (regions or muscles), the camera should be placed at a distance of 1 meter from the examined region (Aljumaah, Samara & Ayadi 2012; Samara et al. 2013).

The thermal imager detects surface heat emitted as infrared radiation and produces an image that is a map of temperature differences. In a cold environment, heat dissipates primarily as non-evaporative heat loss. Heat

Table I. Scoring scale for locomotion in camels based on the position of the dorsal axis of the animal during movement (Escala de puntuación para locomoción en camellos en función de la posición del eje dorsal del animal durante el movimiento).

Qualitative scale	Description
Normal	Stands and walks normally with a level back. Makes long confident strides.
Mildly lame	Stands with flat back, but arches when walks. Gait is slightly abnormal.
Moderately lame	Stands and walks with an arched back and short strides with one or more legs. Slight sinking of dew-claws in limb opposite to the affected limb may be evident.
Lame	Arched back standing and walking. Favouring one or more limbs but can still bear some weight on them. Sinking of the dew-claws is evident in the limb opposite to the affected limb.
Severely lame	Pronounced arching of back. Reluctant to move, with almost complete weight transfer off the affected limb.

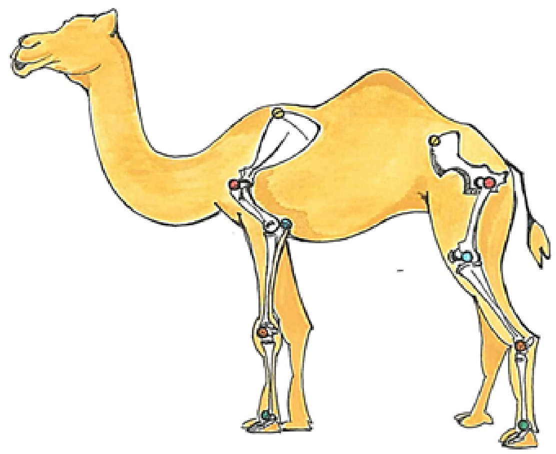

Figure 2. Graphical representation of the joint angles considered (Representación gráfica de los ángulos articulares considerados).

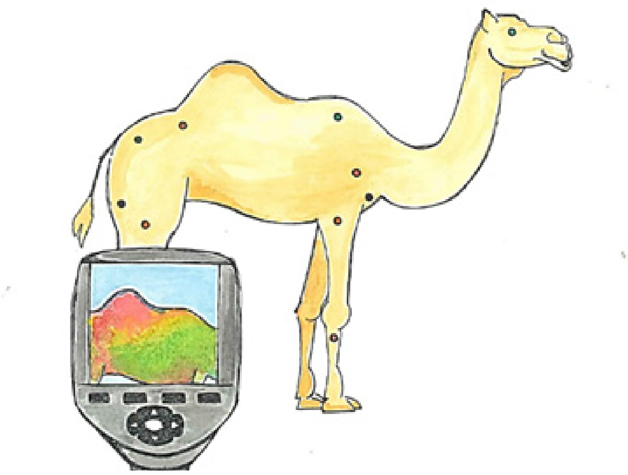

Figure 3. Graphical representation of the thermographic examination. The points indicate the body regions whose temperature was recorded with the thermal imager (Representación gráfica del examen termográfico. Los puntos indican las regiones del cuerpo cuya temperatura se registró con la cámara termográfica).

loss is expressed in watts per square meter (W/m^2) of the animal's surface.

The heat loss rate (W/m^2) is calculated from the neck (the area between the ear, the cross, the elbow and the throat), the trunk (the area from the cross and the point of the elbow to the gluteus) and the inner surfaces of the front and rear legs (the area of the armpit or groin). The neck and trunk were chosen as measuring points for a practical reason: heat loss from these areas can be reduced with a blanket. The front and rear legs were chosen to represent special regions of the body. We calculate the radiated heat of each particular area of the animal by the calculation method derived from the Stefan-Boltzmann Law:

$$P = \varepsilon\sigma(\overline{T}_s^4 - T_a^4)$$

P= emitted power (W/m^2)

ε= emissivity (adjusted on camera, 0.1-1. Previous experiences used 0.95.

σ= Stefan-Boltzmann constant 5,67 x 10^{-8} $Wm^{-2}K^{-4}$

T_s= surface temperature (K)

T_a= air temperature (K)

___= Measure points average

The camera is equipped with a 220*160 field of view lens, with images shown in a focal plane array arrangement. The average surface temperature was calculated from a 0.3 million pixel image of each region. The pixel intensity used in this study was chosen based on the availability of the equipment. The calculations used the average number of pixels that make up each image, with each pixel with an accuracy of 2.5ºC or 2.5%.

The average temperature for each area was determined to compare the changes in the average temperature of the affected surface overtime covered by the training protocol (Hall, Kay & Yarnell 2014; Simon et al. 2006).

The air temperature was recorded to correct the average daily temperature of the surface of the camels by using an adjustment factor of ± 0.5 per degree> or <20ºC of ambient temperature.

For each animal, thermographic images were collected before the start of their kinetic evaluation (baseline), immediately after this evaluation and at 5 minutes post-exercise.

The surface temperature was recorded for the shoulder muscle region, pectoral muscles, forearm, lumbar region, rump, cross, semimembranous and semitendinosus muscles, front extremities, hind limbs and cornea (**Figure 3**).

Thermographic limb exams include giblet of the front and rear limbs (dorsal, lateral and medial view), right and left carpal / tarsal (dorsal, lateral, palmar and medial view), right and left metacarpal/tarsal (dorsal, lateral view and medial), and left flexor tendons (palmar/plantar view), right and left coronary bands

Table II. Movement speed and duration, frequency and lenght of stride in camels (Velocidad de movimiento y duración, frecuencia y longitud del tranco en camellos).

Gait	Speed		Footprint duration (s)	Footprint frequency (steps/min)	Footprint length (m)
	m/s	km/h			
Slow step	1.76	6.3	1.67	35.9	2.93
Fast step	3.31	11.9	0.97	61.8	3.21
Galloping	5.20	18.7	0.56	107.1	2.91

Source: Dagg (1974).

(dorsal view), right and left navicular bones (lateral and medial view), right and left heel bulbs.

All corneal temperatures were measured from the center of the right and left cornea. Likewise, the anterior and posterior areas of both eyes were measured from both sides (Yanmaz & Okumus 2014).

Determination of cortisol levels in saliva

Saliva samples are taken with sterile swabs before and immediately after exercise.

The swab is placed in the oral cavity of the camel at the height of the third upper premolar for approximately 30 seconds (**Figure 4**).

Once the sample is collected, they are refrigerated at 4 ° C for no more than 2 hours before being transferred and frozen at -20 ° C for later analysis.

INTERPRETATION OF RESULTS AND CONCLUSIONS

Among the economic interests for breeding and production of camels, its use as a racing animal, especially in the United Arab Emirates, acquires special relevance, where this tradition is firmly rooted in the ancient Bedouin culture. The monetary value of this production is also represented in other leisure and free-time activities such as tourist walks and exhibitions, in which the camel is the protagonist or claim demanded.

This potential industry, which could be classified as marginal or minor but in full development withing a globalized approach, constitutes the main niche or

Figure 4. Graphical representation of the cortisol sampling in saliva (Representación gráfica del muestreo de cortisol en saliva).

functional segment to which these animals have been relegated in certain geographical locations. This is the case, in particular, of the Canarian camel breed, whose history as beast burdens in agricultural works has been replaced by almost exclusive use for tourism purposes.

The natural gaits for locomotion in camels involves the displacement of the center of gravity of their body forward. Its lateral or posterior oscillation is only evidenced in particular circumstances such as agonistic encounters of a competitive nature between individuals, active avoidance of elements that could disrupt normal gait or during racing competition.

The angulation and general functioning of its musculoskeletal system are intrinsic characteristics perfectly adapted to allow the necessary displacement of the center of gravity in each situation. Similarly, rhythmic movement of the head, trunk and tail, contribute to the maintenance of balance during locomotion (Khan, Arshad & Riaz 2003). The standard values for the speed of movement and for the duration and length of each stride in camels depending on the gear are presented in **Table II.**

The slow step is a synchronized movement in three times in which the weight of the body is supported mainly by both anterior or posterior legs. On the other hand, fast step in camels is characterized by a cadence of movements in two times with sagittal synchrony in which the front and rear ipsilateral limbs advance in unison. This mode of walking is commonly accepted as the camel's favorite for purely evolutionary reasons and with marked heritability (Dagg 1974; Gauthier-Pilters 1958; Khan, Arshad & Riaz 2003).

The qualitative examination of the locomotion is an intuitive, easy-to-apply system of remarkable efficacy in the early detection of osteomuscular alterations in the digital region and the therapeutic monitoring of the prevalence and incidence of these pathologies. The dromedaries with moderate to severe lamenesses must be correctly identified with a view to providing the therapeutic monitoring indicated in each case until their correct functional recovery is allowed.

In this scenario, the biokinetic characterization of the Canarian camels will enrich the enhancement and viability of this breed selection and genetic improvement programs through the constitution of a standardized base of accurate performance records with genealogical base and precise estimations of the influence of factors of diverse nature involved in this functional performance. Based on all possible combinations of information, the breeding value for this functional characteristic could be estimated and, consequently, develop conservation and improvement actions.

Related to this, real-time thermographic evaluation as a complementary analysis tool will be of great value for the definition of objective criteria for detection of lesions associated with the motor activities performed by these animals, as well as for the monitoring of the organic processes that they occur during training and recovery routine, with perspectives to enrich the quality of life in camels.

The association of the previous results with the cortisol levels obtained will allow an informed knowledge of the impact of physical exercise on its general well-being and its practical analytical application on tourist walks or exhibitions that are included in environmental enrichment programs with domestic camels (Majchrzak et al. 2015).

ACKNOWLEDGMENTS

The present research was carried out in the financing framework of the international project CA.RA. VA.N – "Toward a Camel Transnational Value Chain" (Reference APCIN-2016-00011-00-00) and during the covering period of a predoctoral contract (Submodality 2.2 'Predoctoral research staff') funded by University of Córdoba, Spain.

BIBLIOGRAPHY

Abdoun, KA, Samara, EM, Okab, AB & Al-haidary, AA 2012, 'Regional and circadian variations of sweating rate and body surface temperature in camels (Camelus dromedarius)', *Animal Science Journal*, vol. 83, no. 7, pp. 556-61.

Alexander, RM 1996, *Optima for animals*, Princeton University Press.

Alexander, RM 2003, *Principles of animal locomotion*, Princeton University Press.

Alexander, RM, Jayes, A & Ker, R 1980, 'Estimates of energy cost for quadrupedal running gaits', *Journal of Zoology*, vol. 190, no. 2, pp. 155-92.

Alexander, RM, Maloiy, G, Ker, R, Jayes, A & Warui, C 1982, 'The role of tendon elasticity in the locomotion of the camel (Camelus dromedarius)', *Journal of Zoology*, vol. 198, no. 3, pp. 293-313.

Aljumaah, RS, Samara, EM & Ayadi, M 2012, 'Influence of introducing machine milking on biothermal parameters of lactating camels (Camelus dromedarius)', *Italian Journal of Animal Science*, vol. 11, no. 4, p. e73.

Autio, E, Neste, R, Airaksinen, S & Heiskanen, M-L 2006, 'Measuring the heat loss in horses in different seasons by infrared thermography', *Journal of Applied Animal Welfare Science*, vol. 9, no. 3, pp. 211-21.

Bernáth, B, Suhai, B, Gerics, B, Csorba, G, Gasparik, M & Horváth, G 2004, 'Testing the biomechanical optimality of the wall thickness of limb bones in the red fox (Vulpes vulpes)', *Journal of biomechanics*, vol. 37, no. 10, pp. 1561-72.

Blanco, RE & Gambini, R 2006, 'A biomechanical model for size, speed and anatomical variations of the energetic costs of running mammals', *Journal of theoretical biology*, vol. 241, no. 1, pp. 49-61.

Butcher, M, Hermanson, J, Ducharme, N, Mitchell, L, Soderholm, L & Bertram, J 2009, 'Contractile behavior of the forelimb digital flexors during steady-state locomotion in horses (Equus caballus): an initial test of muscle architectural hypotheses about in vivo function', *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, vol. 152, no. 1, pp. 100-14.

Currey, J 1982, 'Bone as a mechanical structure', *Biomechanics: Principles and applications*, pp. 75-85.

Currey, JD 2014, *The mechanical adaptations of bones*, Princeton University Press.

Dagg, AI 1974, 'The locomotion of the camel (Camelus dromedarius)', *Journal of Zoology*, vol. 174, no. 1, pp. 67-78.

Dagg, AI & Vos, Ad 1968, 'The walking gaits of some species of Pecora', *Journal of Zoology*, vol. 155, no. 1, pp. 103-10.

de la Fuente Fernández, JC 2019, 'Tras el rastro de leopardos y panteras en la India', *Quercus*, no. 403, pp. 30-8.

Eddy, A, Van Hoogmoed, L & Snyder, J 2001, 'The role of thermography in the management of equine lameness', *The Veterinary Journal*, vol. 162, no. 3, pp. 172-81.

Gauthier-Pilters, H 1958, 'Quelques observations sur l'écologie et l'éthologie du dromadaire dans le Sahara nord-occidental', *Mammalia*, vol. 22, no. 1-4, pp. 140-51.

Hall, C, Kay, R & Yarnell, K 2014, 'Assessing ridden horse behavior: Professional judgment and physiological measures', *Journal of Veterinary Behavior: Clinical Applications and Research*, vol. 9, no. 1, pp. 22-9.

Howell, AB 1944, 'Speed in animals, their specialization for running and leaping', *Speed in animals, their specialization for running and leaping.*

Janis, CM, Theodor, JM & Boisvert, B 2002, 'Locomotor evolution in camels revisited: a quantitative analysis of pedal anatomy and the acquisition of the pacing gait', *Journal of vertebrate paleontology*, vol. 22, no. 1, pp. 110-21.

Kar, D, Issac, KK & Jayarajan, K 2003, 'Gaits and energetics in terrestrial legged locomotion', *Mechanism and machine theory*, vol. 38, no. 4, pp. 355-66.

Khan, BB, Arshad, I & Riaz, M 2003, *Production and management of camels*, Department of Livestock Management, University of Agriculture, Faisalabad, Pakistan.

Majchrzak, YN, Mastromonaco, GF, Korver, W & Burness, G 2015, 'Use of salivary cortisol to evaluate the influence of rides in dromedary camels', *General and comparative endocrinology*, vol. 211, pp. 123-30.

Maloiy, G, Rugangazi, B & Rowe, M 2009, 'Energy expenditure during level locomotion in large desert ungulates: the one- humped camel and the domestic donkey', *Journal of Zoology*, vol. 277, no. 3, pp. 248-55.

Mazur, D, Herbut, E & Walczak, J 2006, 'Infrared thermography as a diagnostic method', *Roczniki Naukowe Zootechniki*, vol. 33, no. 2, p. 171.

Samara, EM, Abdoun, KA, Okab, AB, Migdadi, H, Sadder, MT, Al-Haidary, AA & Gahlot, T 2013, 'Relationship between coat colour and thermoregulation in Saudi camel breeds', in *Proceedings of the International Camel Conference, Al-Hasa, Saudi Arabia*, pp. 17-20.

Simon, EL, Gaughan, EM, Epp, T & Spire, M 2006, 'Influence of exercise on thermographically determined surface temperatures of thoracic and pelvic limbs in horses', *Journal of the American Veterinary Medical Association*, vol. 229, no. 12, pp. 1940-4.

Sprecher, D, Hostetler, D & Kaneene, J 1997, 'A lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance', *Theriogenology*, vol. 47, no. 6, pp. 1179-87.

Webb, S 1972, 'Locomotor evolution in camels', *Forma et functio. An international journal of functional biology.*

Yanmaz, L & Okumus, Z 2014, 'Using infrared thermography to detect corneal and extremity temperatures of healthy horses', *Israel Journal Of Veterinary Medicine*, vol. 69, pp. 20-3.

Zhihao, LJQXW & Peijun, X 1993, 'Experiment and Analysis of the Camel Gait [J]', *Transactions of The Chinese Society of Agricultural Engineering*, vol. 3.