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Lameness in elephants

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Although lameness is considered the most important clinical sign of musculoskeletal disorders in other species, elephants have been shown to rarely express distinct lameness patterns (Fowler et al., 2006; Lewis et al., 2010). This might even be the case in severe lesions (Lewis et al., 2010). Nevertheless, elephants do express specific alterations in their posture indicative of musculoskeletal disorders. These alterations are visually perceptible for the experienced observer. Therefore it is strongly recommended to be aware of such subtle alterations in the gait and posture of elephants (Schiffmann, 2021). A close monitoring is required to recognize these indicators. With respect to the painfulness of musculoskeletal disorders, the determination and monitoring of even subtle signs of lameness and posture abnormalities are important and helpful in the medical management and care of elephants. The latter might be of peculiar relevance in circumstances where diagnostics such as radiographic imaging or thermography are not available.

To facilitate the corresponding assessment and evaluation, attentively checking the following aspects is recommended.

1. Stiffness of gait and abnormal gait pattern

As mentioned above, obvious lameness is often missed in elephants even in cases of severe musculoskeletal disorders. Nevertheless, the continuous monitoring of an elephants' gait pattern, foot condition and activity level represents a critical part of musculoskeletal health assessment. The more familiar an observer will be with the individual gait pattern and activity level of an elephant, the quicker he will be aware of alterations therein. Video recordings and observation of gait patterns in slow motion might present an important tool and reveal subtle signs such as a shortening of the stride length or duration of the standing leg phase.

2. Weight distribution and posture in a standing position

An elephant with a healthy musculoskeletal system will distribute its body weight evenly on its four legs, although the front legs do physiologically bear more weight than the hind legs (Panagiotopoulou et al., 2012; Schmidt-Burbach, 2009). The leg joints of an elephant allow a distinct range of motion while walking, but show a column-like conformation when the elephant is standing (Fig. 1).

Figure 1 Although elephant legs look quite columnar when standing, in particular the distal joints show a rather large range of motion.

The latter means that in a normally standing elephant the carpal, elbow and shoulder joints of the front and the tarsal, stifle and hip joints of the hind leg are positioned in a vertical axis (Fig. 2a) (Ahasan et al., 2016; Weissengruber et al., 2006). This axis is consistently visible from a lateral as well as a frontal or rear view. When suffering from irritation or pain in a specific foot or leg, the elephant will change from this normal posture to a position allowing it the relief of the affected structure. This may become obvious by shifting weight in a corresponding direction (Figs. 2b-f) or placing the affected foot or leg out of the weight bearing vertical axis. Additionally, a kyphotic posture of the thoracolumbar spine, in order to relieve the front legs, may be observed. In contrast to the African species, this sign will be hard to detect in Asian elephants due to their physiologically kyphotic spine conformation. Such changes in weight distribution and posture due to painful conditions in feet or legs are well-known for domestic species such as horses and cattle (Hood et al., 2001; Poursaberi et al., 2010). Luikart et al. (2005) demonstrated the association of abnormal or unequal weight distribution with the occurrence of chronic untreatable sole ulcerations in two Asian elephants. According to their report, abnormal weight distribution patterns should be considered of relevance since their underlying causes might lead to secondary diseases.

Figure 2 (a) Normal standing posture from a lateral view in a male Asian elephant. (b-f) Stages of increasingly shifting weight to the hind legs in order to relief the affected front limbs. Note that photographs represent animals that are standing, not animals in movement.

3. Positions to relieve a specific limb or joint

In elephants, various postures during standing rest have been reported and are characterized by giving some body weight to external structures by leaning against or placing a body part (trunk, tusks, head, leg) on them (Schiffmann et al., 2018) (Fig. 3).
These behaviours should not a priori be considered indicative of any musculoskeletal health issue. Rather, interpretation should be based on their frequency and intensity of occurrence. As an example, even sub-adult elephants with a perfectly

Figure 3 A female African elephant finding some relief by placing the front foot and the right tusk on steel bars of varying height.

healthy locomotor system may show postures with relieving one leg during daily resting phases. In contrast, elephants suffering from musculoskeletal disorders will express such specific positions much more frequently and independent of resting phases, always relieving the same leg (Fig. 4). Furthermore, they may be observed to use various structures, depending on the enclosure they are kept in. Johnson et al. (2018) report frequent weight shifting between the right and left front feet in a female Asian elephant suffering from a difference in leg length. After improving the latter by the application of glue-on shoes, the shifting behaviour stopped immediately. Intensity and frequency of specific relieving positions may present a helpful indicator for the progression and also treatment effect when monitoring the condition of an affected elephant.

Figure 4 Geriatric female and male Asian elephants intermittently keeping one front foot in a lifted position while eating. In order to maximally relieve this extremity, both elephants repeatedly keep it from the ground for variable amounts of time (seconds up to several minutes).

4. Joint deformities

With respect to the lack of evidence-based reports, it can only be speculated why elephants show joint deformities and presumably associated degenerative alterations mainly in their carpal joints. Although degenerative joint disease has been reported to occur in multiple joints in elephants (Hoby et al., 2014; Luikart & Stover, 2005; Pagan et al., 1999), the carpal joints seem to be prone for these alterations. It was hypothesized that this is due to the unequal weight distribution between front and hind legs (Panagiotopoulou et al., 2012; Schmidt-Burbach, 2009), the enormous forces acting in particular on the distal joints of the extremities (Steinmetz, 2014), or to a correlation with the growth plate closure of the distal limb joints (Kaulfers et al., 2010). Further research would be needed to investigate a corresponding relationship. According to the author's observations, a deformity in the direction of flexion represents an early stage of degenerative alterations in the carpal joint (Fig. 5). Moreover, affected elephants often showed an inwards rotation of both front legs (Schiffmann, 2021).

Continuous monitoring of deformity development, ideally including photographic documentation, is recommended. These data may keep caring staff informed about the progress of joint disorders and enable timely implementation or adaptation of treatment. Radiographic imaging may represent another practical tool to diagnose and monitor joint deformities and severity of chondral degeneration. Although radiologic protocols for the elephant's limbs are available, a proper investigation of the more proximal joints can be complicated by the tissue masses surrounding them and the technique depends heavily on the training status of the elephant (Hittmair et al., 2000; Kaulfers et al., 2010).

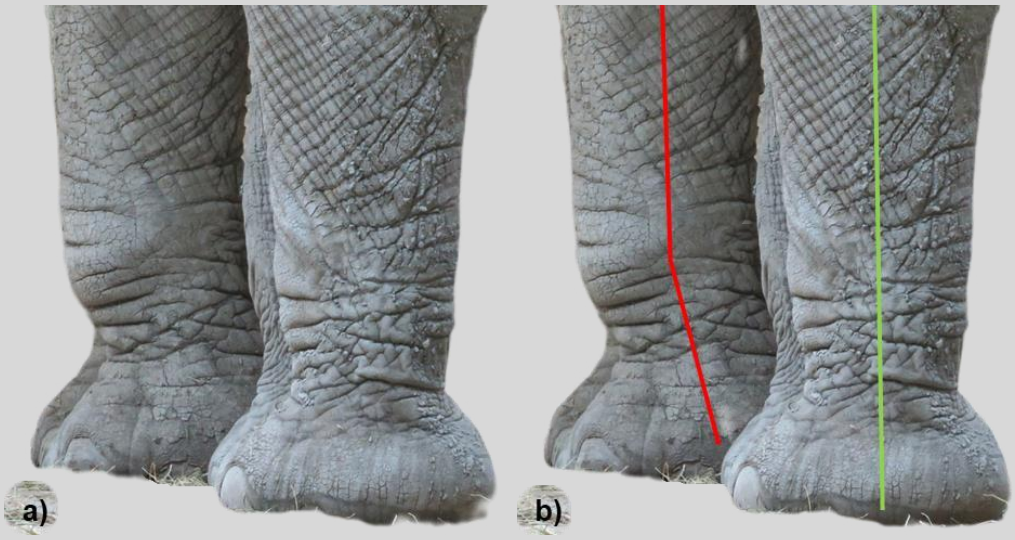

Figure 5 (a) Comparison of the carpal joint of a young-adult and a geriatric female African elephant standing right next to each other. (b) In the young-adult, the mechanical axis runs in a straight vertical line through the centre of the antebrachium, carpal joint and foot (green line). In contrast, there is a distinct angle of the mechanical axis in the carpal joint of the geriatric elephant (red line).

5. Secondary traces

With increasing severity of the musculoskeletal disorder, the elephant will extend the amount of time spent in specific relieving positions (e.g. increased leaning rest vs. lying rest) (Schiffmann et al., 2018). This change in behavioural patterns may lead to visually perceptible traces on the body of an elephant. The longer an elephant expresses relieving positions, the more extended secondary traces will be visible. To recognize them and figure out their etiopathogenesis, it is necessary to take an elephant’s behaviour and interactions with specific structures of the environment into account. This should include day- as well as night-time behaviour and enclosures. Apart from skin alterations, a swelling on the tail base due to excessive leaning, and even traces on the tusks have been described (Schiffmann et al., 2018). Furthermore, relieving positions as well as joint deformities lead to an uneven abrasion of the nails and pad. Depending on the specific conformation and pressure distribution, this will lead to a lack of wear and subsequent overgrowth of certain toenails (Fig. 6). At the same time other toenails may show signs of stress (e.g. recurrent cracks or chronic nail abscesses). Although continuous foot care will be required to control these alterations, they may persist as long as the underlying cause is not addressed and resolved (Luikart & Stover, 2005).

Figure 6 Unevenly worn and overgrown toe nails in the front foot of a female African elephant suffering from post-mortem confirmed severe degenerative joint disease and deformities in her carpal joints.

Conclusions

By continuously monitoring, assessing and documenting in a standardized manner all these aspects of an elephant's gait and posture, mahouts, elephant managers and veterinarians may be up to date of an individual's musculoskeletal health status. This will allow the timely implementation and adaptation of treatment. There is no doubt that visual and tactile examination has limitations compared to radiography and thermography (Miller et al., 2016). Further diagnostic tools to determine degenerative joint disease in elephants such as 3D radiographs and collagen biomarkers are being developed (Bentley et al., 2018; Kilgallon et al., 2015). In contrast to these sophisticated techniques, the visual approach represents a cheap, non-invasive diagnostic tool, which can even be applied from a certain distance. The latter might be of relevance especially in less cooperative or aggressive elephants. In addition, continuous behavioural observations should be conducted directly or by a closed circuit television (CCTV) system. Furthermore, gait observations including slow motion video recordings should be considered in training programs for elephant keepers.

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