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ABSTRACT: This study describes the use of allometric scaling in five giant anteaters (*Myrmecophaga tridactyla*) submitted for osteosynthesis, gastrostomy, or treatment of burns. Chemical restraint was performed by allometric scaling using the dog as a reference; acepromazine (0.06 mg/kg), diazepam (0.3 mg/kg), ketamine (8.8 mg/kg), and buprenorphine (5.9 µg/kg) were combined, and the animals were maintained under isoflurane anesthesia. Heart rate, respiratory rate, hemoglobin oxygen saturation, temperature, and anesthetic depth were measured. Postoperative treatment consisted of ketoprofen, buprenorphine, and ceftiofur. Anesthetic induction was obtained in 10–15 min, achieving muscle relaxation and absence of excitement. Physiologic parameters were stable during the procedures, and postoperative treatment was effective. Allometric scaling was effective for chemical restraint and postoperative treatment.

Key words: Allometric scaling, chemical restraint, giant anteater, inhalant anesthesia, *Myrmecophaga tridactyla*.

The giant anteater (*Myrmecophaga tridactyla*) belongs to the extant order Xenarthrans, family Myrmecophagidae, and is found from Central America to South America (Eisenberg and Redford, 1999). The species is considered to be vulnerable (IUCN, 2007), particularly to farmland encroachment, fires in animal reserves (Silveira et al., 1999), and road kills (Fischer, 1997), all of which account for this species frequently being submitted to veterinary clinics. Mymercophagids have morphologic characteristics that are different from any other mammalian family, making it a challenge to define treatment regimens and to find reliable data on physiologic variations, especially as relate to anesthesia states. Allometric scaling allows the approximation of drug doses for wild animals based on those used in domestic animals (Sedgwick et al., 1991). This is accomplished using mathematical calculations based on physiologic parameters that compare animals of differing sizes and metabolic rates.

This study reports the effectiveness and safety of the dose usage of several drugs previously extrapolated from the dog (*Canis familiaris*), by allometric scaling; drugs were applied to the giant anteater to execute chemical restraint, analgesia, and antibiotic therapy in several surgical procedures.

The study involved five adult giant anteaters, weighing 27.8±4.6 kg, which were brought to the Veterinary Hospital of the University of Franca by forest rangers of São Paulo State, Brazil. The animals were transported in restraint boxes and their weight was determined; sex was not determined due to the difficulty in differentiation. The animals were subjected to osteosynthesis ($n=3$), gastrostomy ($n=1$), and curettage and cleansing of wounds caused by burn ($n=1$).

After 12 hr fasting, animals were chemically restrained by intramuscular (IM) administration of the drugs via blow dart. Doses were calculated by allometric scaling using a 20-kg dog as the reference factor. To facilitate the achievement of a fixed-dose/kilogram for giant anteaters, it was standardized for a target animal weighing 40 kg. The following allometric parameters and formulas were needed to calculate drug dosages: W=weight of the

TABLE 1.   Drugs used in giant anteaters (*Myrmecophaga tridactyla*) obtained by allometric scaling with the dog (*Canis familiaris*) as a reference.

Parameter	*Canis familiaris*		*Myrmecophaga tridactyla*	
Weight (W; kg)	20		40	
SMEC = $K(W^{-0.25})^a$	33.17		19.52	
	Dose (ref)	Dose factor (Dose/SMEC)	Dose factor (dog-ref.)	Target dose (DF×SMEC)
Acepromazine (mg/kg)	0.1	0.003	0.003	0.06
Diazepam (mg/kg)	0.5	0.015	0.015	0.3
Ketamine (mg/kg)	15	0.452	0.452	8.8
Buprenorphine (µg/kg)	10	0.301	0.301	5.9
Ketoprofen (mg/kg)	1	0.030	0.030	0.6
Ceftiofur (mg/kg)	4.4	0.132	0.132	2.6

[a] SMEC=Specific minimum energy cost (SMEC); K-constant: dog=70, giant anteater=49.

animal in kg; K=group constant (placental mammals=70; marsupials and edentates=49); specific minimum energy cost (SMEC; Kcal/kg per day)=K $(W_{kg}^{-0.25})$; dose factor (dog)=drug dose (dog)/SMEC (dog); target dose=dose factor (dog)× SMEC (target animal).

Chemical restraint was based on the association of acepromazine (Acepran®, Univet, Fozdo Igucu, Brazil), diazepam (Compaz®, Cristália, São Paulo, Brazil), and ketamine (Dopalen®, Vetbrands, Paulínia, Brazil) (IM); analgesia was based on buprenorphine (Temgesic®, Schering-Plough, Rio de Janeiro, Brazil) and ketoprofen (Ketofen®, Merial, Campinas, Brazil; IM); and antibiotic therapy constituted of ceftiofur (Excenel®, Pfizer, São Paulo, Brazil; IM; Table 1). Anesthetic maintenance proceeded with isoflurane (Isoforine®, Cristália), diluted in 100% oxygen, via facial mask in a semi closed-circuit system with a calibrated vaporizer. Hydration was maintained with 10 ml/kg per hr of 0.9% saline solution after puncture of the saphenous vein with a 20 G catheter, and body temperature was maintained using a thermal mattress.

The following parameters were monitored during the procedures: heart rate (HR) using electrodes positioned on the arms and legs (lead II; Ecafix®, TEB, São Paulo, Brazil); respiratory rate (*f*) based on thoracic movements; hemoglobin oxygen saturation (SpO_2; Pulse oximeter, Nellcor, Boulder, Colorado) using a tongue sensor on the ear; rectal temperature (T°); and anesthetic depth, which was mainly characterized by eye rotation and the lack of palpebral reflex. Postsurgical treatment was based on buprenorphine every 24 hr and ketoprofen and ceftiofur every 48 hr, with intervals also established by allometric scaling using the dose factor as well as the time factor. Statistical analyses were performed by an analysis of variance for paired samples followed by Dunnett's test for comparisons to baseline levels (beginning of inhalant anesthesia). Differences were considered significant when $P<0.05$. All results were expressed as means±standard deviation.

The latency period for chemical restraint was between 10 and 15 min, after which adequate muscle relaxation and absence of undesirable effects, such as excitement or convulsion, were achieved. The procedures lasted 110–160 min with an average rate of isoflurane of 1.1±0.1V%. During the procedures, HR was maintained at 58±4 beats per min (bpm), *f* at 5±2 movements per min (mpm), SpO_2 at 93±0.5%, and a rectal T° of 32.0±0.4 C (Table 2). None of the parameters differed from their baseline values (0 min) except SpO_2, at 10–70 min.

TABLE 2. Physiological parameters of giant anteaters (*Myrmecophaga tridacttla*) submitted to isoflurane anesthesia.

Parameter[b]	Minutes[a]												
	0	10	20	30	40	50	60	70	80	100	120	140	160
HR	61±19	54±12	53±12	59.2±17	50.5±12	50±9	56±5	55±2	61±18	59±11	56±16	53±10	57±12
f	5±0.8	5±1.0	4±1.0	4±0.0*	5±1.9	5±1.5	4±1.1	4±0.9	4±0.8	6±3	9±6	5±2	5±1
SpO$_2$	91±0.7	96±0.7*	94±0.0*	94±0.0*	93±0.7*	94±1.4*	93±0.0*	94±0.0*	93±0.7	92±1.4	92±0.0	92±0.3	92±0.8
T°	32.4±0.6	32.4±0.6	32.4±0.8	32.2±0.5	32.1±0.4	32.0±0.4	31.9±0.4	31.9±0.3	31.9±0.4	31.9±0.4	31.8±0.4	31.8±0.6	31.8±0.4
Iso V%	0.9±0.2	1.1±0.6	1.1±0.3	1.1±0.3	1.1±0.3	1.1±0.3	1.2±0.9	1.0±0.7	1.3±0.6	1.2±0.5	1.0±0.4	1.1±0.1	1.0±0.0

[a] *=Statistical difference in relation of zero minute.

[b] HR=heart rate; *f* =respiratory rate; SpO$_2$=hemoglobin oxygen saturation; T°=rectal temperature; Iso V%=rate of isoflurane.

In addition, palpebral reflex, which was usually absent during the procedures, and eye rotation were evaluated. It is stressed that this species shows medialization of the eye, which is very similar to that seen in horses. We also evaluated for superficialization such as limb or head movement. Their nocturnal habits did not permit the evaluation of recovery time with precision; however, all animals readily moved around in the stall and searched for food at night. During the postoperative period, no infections were observed on the surgical wounds, and the animals subjected to osteosynthesis did not show movement restriction.

To our knowledge, cases concerning giant anteater anesthesia are relatively scarce, especially regarding procedures that use allometric scaling. For successful chemical and physical restraint, anatomic and physiologic characteristics of this family must be taken into consideration. The safety of the attending personnel is very important, considering that these animals have powerful claws. Due to their heterothermic characteristic, their restraint should be avoided during cold days or on days of abrupt temperature changes (Miranda and Costa, 2006).

Ketamine in edentates is recommended by Gillespie (1993) at a dose of 10–20 mg/kg. The exclusive use of ketamine should be avoided as it can cause catatonia and involuntary movements and, thus, it is recommended that ketamine be combined with 0.1 mg/kg diazepam. According to the same author, the use of xylazine should be avoided due to the risk of regurgitation, which could promote obstruction of the airways; this is very dangerous because orotracheal intubation is impractical. The choice of combining diazepam with ketamine occurred due to hypotension caused by xylazine, as already described in other species (Haskins et al., 1986; Queiroz-Neto et al., 2000). Acepromazine was added to potentiate the dissociative anesthesia employed. The chemical restraint used proved to be

effective, as the latency period was relatively short, and there were no undesirable effects such as agitation, catalepsy, or even convulsion. The anesthetic maintenance with isoflurane offered freedom with regard to surgery time. Nunes et al. (2006) indicated halothane or isoflurane as inducers (3–5 V%) and for anesthetic maintenance (1–2 V%) in these animals. The animals remained anesthetized with minimal vaporization, as recommended by Nunes et al. (2006), and with minimal physiologic alterations, suggesting an effective analgesic therapy which enhanced the inhalant anesthesia.

Although there are no solid analgesic treatment parameters for giant anteaters, it is presumed that the procedures in this report cause noxious stimulation. For this, an opioid and anti-inflammatory therapy was established. Buprenorphine was used due to its prolonged action, as verified in other species (Robertson et al., 2003; Carregaro et al., 2007); a key point in postoperative treatment is decreasing physical restraints after surgeries. It is believed that the doses and intervals of buprenorphine and ketoprofen, for 7 days, were sufficient because the animals moved normally in the stall in the postoperative period; and that the ceftiofur was effective in infection control as well. Although there are other cases of opioid use in edentates (armadillos), it was used only as chemical restraint (Deem and Fiorello, 2002). The latter cited authors affirm that a combination of fentanyl and droperidol, at doses equivalent for dogs, results in unsatisfactory restraint and prolonged recovery time. Gillespie (1993) recommends 0.8 and 1.2 mg of etorphine in edentates, a dose with which he obtained excellent restraint without showing spontaneous movements and catatonia.

Physiologic parameters were unchanged during the procedures, in spite of the oscillation of SpO_2. The low basal values were probably due to the chemical restraint, hindering the exchange of gases. After starting a 100% O_2 supply, SpO_2 values were acceptable, although always just below the lower limit of the normoxia range (McDonell and Kerr, 2007). Due to the impossibility of intubation, it is possible that the mask might have accumulated expired CO_2 over time, reducing the rate of inspired O_2 (Casati et al., 1998). Meanwhile, hypothermic patients (in this case a physiologic situation) would be at lower risk due to the low tissue metabolism (McDonell and Kerr, 2007). The stability, as well as the medialization, of the eye was a good indication of satisfactory anesthetic depth. However, HR and f values remained below those reported by Deem and Fiorello (2002; HR=110–160 bpm, f =10–30 mpm), probably due to the inhalant anesthesia. Body temperature oscillated between 31 and 32 C, staying in the physiologic range of the species (Deen and Fiorello, 2002).

It can be concluded that the use of allometric scaling of chemical restraint and postoperative care was effective and safe because the animals did not show any significant physiologic changes during the procedures, and they showed good anesthetic recovery, seeing that they searched for food and walked normally in the postoperative period.

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