Electrocardiographic Parameters in the Gomeran Giant Lizard, *Gallotia bravoana*

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ABSTRACT: Electrocardiographic parameters were determined for one of the most endangered species in the world, the Gomeran giant lizard, *Gallotia bravoana*, with a population of only ten captive individuals in the world. Heart rate, rhythm, amplitude of P, R, S and T waves, interval of RR, PR, QT and ST waves, duration of P, QRS, T waves, description of SV wave (representing depolarisation of the sinus venosus), mean electrical axis, and correlation with cloacal temperature and weight were determined in this population. Electrocardiographic tracings showed a positive QRS complex, presence of an SV wave, and T waves occasionally negative. Positive correlation was observed between electrical axis and weight, P duration and ambient temperature, and S amplitude and cardiac frequency. Negative correlation was observed between electrical axis and cloacal temperature, S-T duration and the ambient temperature, R-R interval and the cloacal temperature, and R-R interval and cardiac frequency. This is the first complete description of the electrocardiographic parameters of a giant lizard of Lacertidae family and genus Gallotia.

KEY WORDS: Gomeran giant lizard, *Gallotia bravoana*, electrocardiography, diagnostic, cardiology.

INTRODUCTION

To date, the reptilian electrocardiogram (ECG) has been used as a diagnostic tool in cases of clinical cardiac disease and for monitoring anaesthesia (Cook & Westrom, 1979, Anderson, *et al*, 1999). However, its use is limited by the paucity of clinically relevant published material on the subject. To the authors' knowledge, ECG has been fully described in only a few squamata including green iguana, *Iguana iguana*, (Albert, *et al*, 1999) brown tree snake, *Boiga irregularis*, (Anderson, *et al*, 1999), rat snake, *Elaphe obsoleta*, (Jacob and McDonald, 1975), carpet python, *Morelia spilota variegata*, (Rishniw and Carmel, 1999), Indian python, *Python molurus*, (Snyder, *et al*, 1999) and Gallot's lizard, *Gallotia galloti* (de Vera and Gonzalez, 1999, de Vera, *et al*, 2000). This report describes the ECG of the Gomeran giant lizard, *Gallotia bravoana*. The Gomeran giant lizard, previously known only from subfossil material, was first discovered alive in the middle of 2000 (Nogales, *et al*, 2001). With only ten captive animals, and ten known in the wild, it is perhaps the most endangered species of reptile at this time. The present work was done within a larger framework of overall health assessment that included hematologic, coprological, urinalysis, radiographic and microbiological examination and description. The goal of this study was to describe the normal ECG and compare it with other similar species. Moreover, knowledge of the physiological parameters of the species is essential to avoid or prevent diseases that can compromise any recovery program. The need for baseline information goes beyond the health of individuals or even small populations of animals, as is the case of this lizard (Martìnez-Silvestre, 2002). This information, added to hematological and other physiologic parameters, will be a important tool that contribute to the preservation of the species.

MATERIAL AND METHODS

Animals – The six animals came from rocky areas of Valle Gran Rey on Gomera Island (27° 40' N, 18° 0' W), in the Canary Islands, Spain. All the lizards were kept in pairs for two years and subjected to identical ambient conditions that they received in wild. Animals had been fed regularly on a diet of fruit, vegetables, and endemic plants from the island, supplemented with insects (crickets, giant mealworms and locusts) and water *ad libitum*. Lizards were maintained on a natural photoperiod of 14 hr light and 10 hr dark. Day time air temperatures ranged from 23 to 35°C (73 – 95°F) and terrariums were maintained at the same temperature. The lizards were all eating, drinking and behaving normally. All animals were clinically healthy at the start of the study. All the lizards were adults, with measurements of lizard 1: 123.3 g and 34.4 cm; lizard 2:104.98 g and 36.5 cm; lizard 3: 162.56 g and 27.7 cm; lizard 4: 148.05 g and 35.2 cm; lizard 5: 244.2 g and 46.4 cm; and lizard 6: 212.2 g and 45.6 cm. This study was approved by the Animal Care and Use Committee and supported by the government of the Canary Islands.

Measurements – Waves and registers were obtained by a portable electrocardiograph (MEGOS Astron, mod. Replay, Barcelona, Spain). Electrodes were applied to the body surface with alligator clips. In lizards, this non-invasive method can provide a consistent ECG signal and a good interpretation and is easy to apply. Placement was adjusted to maximize the amplitude of the QRS complex. The head was wrapped with a soft bandage to reduce visual stimuli and immobilise the lizard. Recording of ECG tracings was begun 30 seconds after the lizard became inactive. Electrodes were attached using standard protocols in small animals but adapted to the cervical region of reptiles following the system described for squamata (Mullen, 1967, Valentinuzzi, *et al*, 1969, Albert, 1999). Diagram 1 shows the electrode placement used and the three bipolar derivations obtained in this work.

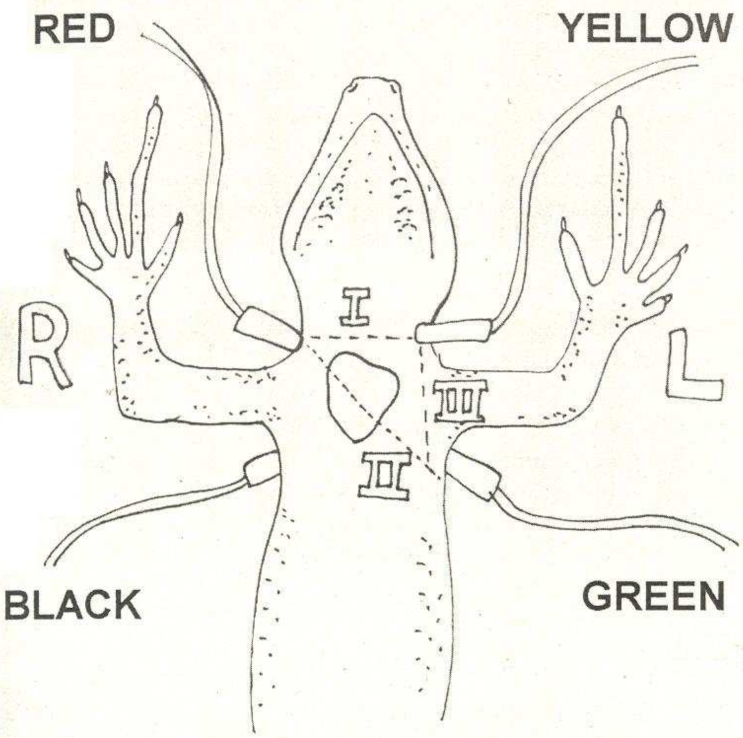

Diagram 1. Electrocardiogram lead placement on Gomeran giant lizards: red electrode, right side, between gular area and shoulder; yellow electrode left side, symmetrical to red electrode; black electrode, right side, caudal and slightly dorsal to anterior leg; green electrode, left side, symmetrical to black electrode.

	Mean	Range	Standard Dev.
Weight (g)	166	105 – 244	53
Ambient Temp, °C (°F)	20 (68)	20 – 21 (68 – 70)	0
Internal Temp, °C (°F)	21 (70)	18 – 24 (64 – 75)	3
Heart rate (bpm)	44	35 – 60	9
R-R interval (sec)	1.43	1.05 – 1.78	0.3
P duration (sec)	0.09	0.08 – 0.1	0.01
P amplitude (mV)	0.08	0.05 – 0.1	0.3
P-R interval (sec)	0.15	0.1 – 0.18	0.03
R amplitude (mV)	0.15	0.1 – 0.18	0.03
QRS duration (sec)	0.08	0.05 – 0.1	0.02
Q-T interval (sec)	0.21	0.1 – 0.32	0.09
S-T interval (sec)	0.14	0.02 – 0.2	0.07
S amplitude (mV)	0.03	0.02 – 0.05	0.01
T duration (sec)	0.12	0.1 – 0.15	0.03
T amplitude (mV)	0.07	0.03 – 0.14	0.04
SV amplitude(mV)	0.12	0.04 – 0.2	0.05
SV duration (sec)	0.13	0.08 – 0.2	0.05
Mean electrical axis (°)	80	45 – 135	44
Q-T:R-R ratio	0.15	0.06 - 0.26	0.07
PR:RR ratio:	0.1	0.09 - 0.13	0.02

Table 1. Electrocardiographic measurements of the Gomeran giant lizard, *Gallotia bravoana*, recorded at 25 mm/sec and 10 mm/mV.

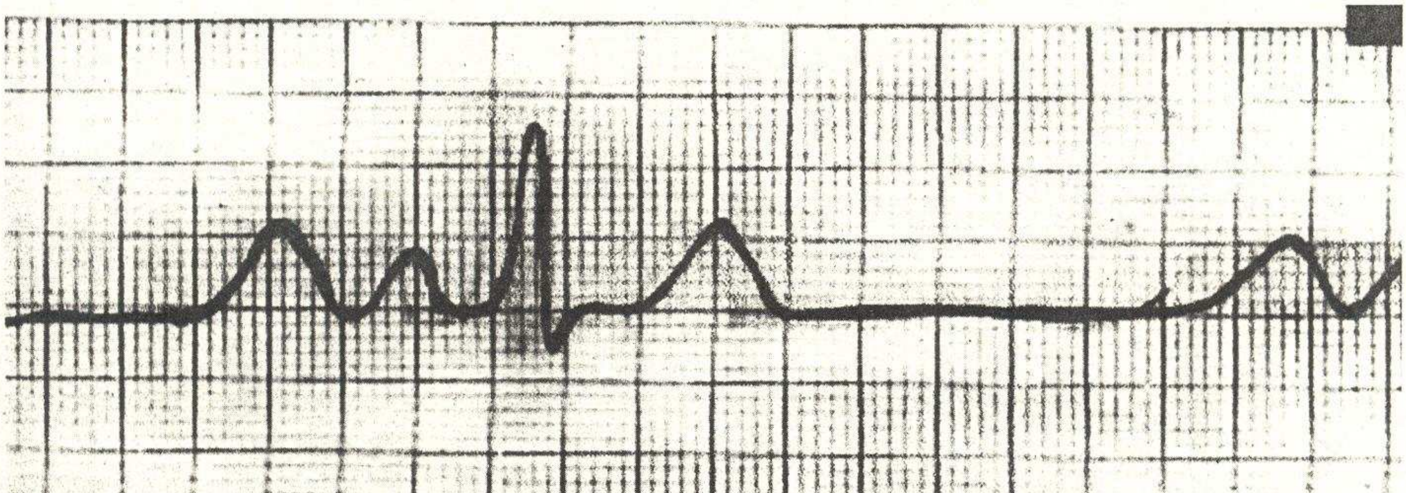

Figure 1. Electrocardiogram in the Gomeran giant lizard, *Gallotia bravoana* using the mean values. Ratios have been modified to best fit the tracing (50 mm/sec and 30 mm/mV).

In each lizard, six leads were evaluated and heart rate, rhythm, amplitude of P, R, S and T waves; interval of RR, PR, QT and ST waves, duration of P, QRS, T waves, description of SV wave (representing depolarisation of the sinus venosus) were analysed using lead II. Tracings were recorded with a paper speed of 25 mm/sec and a sensitivity of 10 and 20 mm/mV.

The mean electrical axis was obtained by the Bucher method (Bucher, 1969), due to the low surface electrical potentials of the Gomeran lizards. This method permits calculation of the QRS vector in a horizontal plane using the positive or negative oscillation of each derivation in the six derivations commonly registered. When these oscillations are calculated, mean electrical axis can be obtained by application of each value in a standard round table (Cabrera's circle).

Statistical analysis was performed with statistics software (SPSS-PC, SPSS Inc., Chicago, IL). Only those results with a correlation coefficient > 0.8 and a $p < 0.05$ were considered statistically significant. Due to the low number of animals available, a non parametric test (Kruskal Wallis test) was used to study significant differences.

Results

The following waves were observed: P, Q (very difficult in some cases), R, S, T and SV (corresponding to depolarisation of the posterior sinus venosus) as described in squamata (Lawton & Cooper 1999). Results are shown in Table 1. A schematic ECG is represented in Figure 1.

A statistically significant positive correlation was observed between electrical axis and weight, P duration and ambient temperature and finally S amplitude and cardiac frequency. Furthermore, a statistically significant negative correlation was found between electrical axis and cloacal temperature, S-T duration and the ambient temperature, R-R interval and the cloacal temperature and finally R-R interval and cardiac frequency.

All lizards had a sinus rhythm with a P wave for each QRS complex. R waves were most commonly positive (5 positive / 1 negative) and biphasic. P and T waves were generally positive, although T waves were occasionally negative (4 positive / 2 negative). Pleomorphic P waves also occurred and were often difficult to separate from the SV wave.

Discussion

The electrical amplitude of the measured waveforms was often under 1.0 mV, so equipment with good sensitivity (at least 20 mm/mV) is required. The background interference associated with skeletal muscle activity may obscure cardiac waveforms (Murray 1998). In this study, the lizards were immobilised with a non-stressful method (a head wrap), which eliminated disturbance due to skeletal muscle activity. Special care was taken to avoid excessive ocular pressure to prevent the cardiac vasovagal effect that could affect the ECG results.

There was a positive correlation between weight and cardiac axis.. This data has also been observed in captive green iguanas in Spain (Albert, 1999). In our animals, this relationship is linear but the low number of lizards makes it impossible to establish a clinically useful formula that permits calculation of the degree of axis rotation according to weight. Correlations between ambient and cloacal temperatures were also observed. Although high temperature increased the P segment, it decreased S-T duration, R-R duration and cardiac axis. This effect of temperature in ectotherms is not unusual and has also been described for other species of squamata (Jacob and McDonald, 1975, Cook and Westrom, 1979). As consequence, a special homeostatic adaptation to different degrees of thermal variation due to the ecological particularities of the rocky, warm and sunny areas where these giant lizards live is suspected. Statistical correlations are of great importance to understand the cardiac status in these lizards. However, these statistic results are limited to only six lizards, more numbers are needed to reliably interpret ECG's.

Electrocardiogram can be a useful tool for diagnosis of heart disease. These lizards have been diagnosed with diseases that can affect cardiac function as in metabolic bone disease or calcium depletion in one female (Martìnez-Silvestre, *et al*, 2001) or vascular lesions due to hemoparasites in peripheral blood of all captive individuals (Martìnez-Silvestre, *et al*, 2001). Possible cardiac alteration can be detected using ECG techniques. Moreover, ECG can also be a good method for monitoring anaesthesia during surgery. Further research on lizard's ECG with other similar species and greater sample size will be needed to diagnose the variety of cardiac lesions (arrhythmias, congenital diseases or chamber enlargements), effects of drugs (anaesthesia, cardiac drugs) or metabolic changes (gravidity, calcium depletion, etc).

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References

Albert A, Bayón del Rio A, Fernández de Palacio MJ, Talavera J, Brotons N. 1999. Parametros electrocardiográficos normales en la iguana verde (*Iguana iguana*) y en el galápago de Florida (*Trachemys scripta elegans*). XXXIV Congreso Nacional de AVEPA: 242.

Anderson NL, Wack RF, Calloway L, Hetherington TH, Williams JB. 1999. Cardiopulmonary effects and efficacy of propofol as an anesthetic agent in brown tree snakes, *Boiga irregularis*. BARAV, 9(2):9-15.

Bucher HW. 1969. Klinische diagnostik erworbener und angeborener Herzfehler. Schwabe, Basilea/Stuttgart.

Cook R, Westrom W. 1979. Cardiac anatomy, cardiac physiology and electrocardiology of reptiles. Proc AAZV, 16-22.

De Vera L, Gonzalez J. 1999. Power spectral analysis of short-term RR interval and arterial blood pressure oscillations in the lizard, *Gallotia galloti*: effects of sympathetic blockade. J Exp Zool, 283:113-120.

De Vera L, Gonzalez J, Pereda E. 2000. Relationship between cortical electrical and cardiac autonomic activities in the awake lizard, *Gallotia galloti*. J Exp Zool, 287:21-28.

Jacob JS, McDonald HS. 1975. Temperature preferences and electrocardiography of *Elaphe obsoleta* (Serpentes). Comp Biochem Phys A, 52(4):591-4.

Lawton M, Cooper JE. 1999. Manual of Reptiles. British S An Vet Ass, London:250.

Martìnez-Silvestre A, Mateo JA, Soler Massana J, Pether J. 2001. Cl'nica y conservación del lagarto gigante de La Gomera. Animalia, 136:54-57.

Martìnez-Silvestre A, Mateo JA, Silveira LS, Bannert B. 2001. Presencia de protozoos intraeritrocitarios en el lagarto gigante de La Gomera (*Gallotia simonyi gomerana*). Boletin Asociacion Herpetologica Espanola, 12(2):90-92.

Martìnez-Silvestre A. 2002. Aspectos cl'nicos en la conservación del lagarto gigante de La Gomera. Simposium Internacional de Conservacion de especies amenazadas I. 1-3.

Mullen RK. 1967. Comparative electrocardiography of the Squamata. Physiol Zool, 40:14-126.

Nogales M, Rando JC, Valido A, Martin A. 2001. Discovery of a living giant lizard, genus *Gallotia* (Reptilia: Lacertidae), from La Gomera, Canary Islands. Herp, 57:169-179.

Rishniw M, Carmel BP. 1999. Atrioventricular valvular insufficiency and congestive heart failure in a carpet python. Australian Vet J, 77(9):580-3.

Snyder PS, Shaw NG, Heard DJ. 1999. Two-dimensional echocardiographic anatomy of the snake heart (*Python molurus bivittatus*). Vet Radiol Ultrasound, 40(1):66-72.

Valentinuzzi ME, Hoff HE, Geddes LA. 1969. Electrocardiogram of the snake: effect of the location of the electrodes. J Electrocardiology, 2(3):245-52.