JOURNAL OF PURE AND APPLIED MICROBIOLOGY, May 2014. Vol. **8**(Spl. Edn. 1), p. 267-271

Aerobic and Anaerobic Metabolism of the Snake, *Eryx jayakari*, during Resting and Activity under Experimental Different Temperatures

Mohammed K. Al-Sadoon[1*], Saleh A. Kandeal[1] and Fahad S. Al Otaibi[1]

[1]Department of Zoology, College of Science, King Saud University P.O. Box 2455, Riyadh 11451, Saudi Arabia.

(Received: 11 March 2014; accepted: 29 April 2014)

Few studies investigating metabolic rate of Arabian Peninsula were done especially those concerning snakes. This study was designed to determine the association of metabolic rate of the snake, Eryx *jayakari*, during resting and activity states with aerobic and anaerobic respiration under different temperature zones. A total number of 25 immature specimens of *E. jayakari* was collected from Riyadh region of Saudi Arabia. Oxygen consumption rate and total lactate production for resting and active snakes were determined at 15°, 20°, 25°,30°, and 35°C. The results showed that resting and active oxygen consumption and aerobic scope increased gradually with rising temperature. The differences in oxygen consumption between resting and active states were significant ($P \leq 0.05$). The highest Q10 value was obtained at 30°-35°C. There was a proportional relationship between elevated temperature and production of lactic acid either in resting or active snakes. The value of Q10 during anaerobic scope was the highest at 25°-30°C. There was a proportional increase in ATP molecules (µmoles/g/2min) during aerobic or anaerobic respiration as well as total metabolic scope with the increase in ambient temperature.

Key words: Aerobic, Anaerobic, Respiration, Metabolic rate, Eryx *jayakari*.

Metabolic energy of most animals could be measured by estimating oxygen consumption rate during resting and activity as the oxygen volume consumed per one gram of body weight per hour (ml O_2/g/hr). For most reptilian species, as ambient temperature increases, body temperature is increased consequently, oxygen consumption is increased (Al-Farraj, 1993; Rodiny, 2006; Al-Shammari, 2007). For reptiles, oxygen consumption was greater during activity than that during resting at temperatures less than preferred body temperature (PBT), while it reached its peak at PBT (Al-Sadoon, 1983; Rodiny, 2006). It is also known that reptiles employ anaerobic metabolic scope (derived from the difference in lactate concentration between active and resting animals) as a major energy source during the initial stages. The total metabolic scope (aerobic and anaerobic) is greatest at PBT (Al-Sadoon, 1986). Few studies investigating metabolic rate of Arabian Peninsula reptiles have been done especially those concerning snakes. Al-Sadoon (1991) used a closed double chamber system, at temperatures ranging from 5°C to 35°C found an elevated metabolic curve in immature *Cerastes gasperettii* and *Malpolon moilensis* compared to matured ones. However, the metabolic curve was greater in *Vipera berus* (from cold zones) than that of the other two species. The author justified this difference due to the adverse effect of climatic conditions on metabolic energy of the snakes. Therefore, the present study was designed to determine the association of metabolic rate of the snake *Eryx jayakari* during

* To whom all correspondence should be addressed.
Tel.: 00966555489618; Fax: 00966114674253;
E-mail: msadoon@ksu.edu.sa.

resting and activity states with aerobic and anaerobic respiration under experimental temperatures ranging 15°C to 35°C. The study also investigated the contributions of aerobic and anaerobic respiration to the total metabolic scope which utilized mainly during the snake's activity.

MATERIALS AND METHODS

Immature specimens (n=25) of the sand boa, Eryx jayakari was collected from the study area, Riyadh region of Saudi Arabia by monthly field trips. The collected samples were then immediately transferred to the reptilian laboratory in Zoology Dept., College of Science, King Saud University where they were housed in glass boxes containing soft sand with food and water provided and light/dark cycle of 12 hr each at room temperature (22-24°C). The snakes remained in good health in terms of body condition and activity level throughout the experimental period, however; they were fasted for at least 3-7 days prior to use. They were divided into two groups, one for aerobic (nP% 5) and the other (nP% 20) for anaerobic measurements.

Determination of resting and active oxygen consumption

Oxygen consumption rate for resting and active immature snakes (nP% 5) was determined at 15°C, 20°C, 25°C, 30°C and 35°C using a double-chamber volumetric system (Al-Sadoon and Spellerberg,1985). Oxygen consumption was estimated according to gasses law ($\dot{V}O2$ at STP, standard temperature and pressure) and thermal quotient Q10. Active metabolism estimates were obtained according to Al-Sadoon (1987) and Al-Otaibi (2012) using another 5 immature snakes subjected to electrical stimulation. Each snake was weighed, placed into the sealed animal chamber of the volumetric system and exposed to electrical shocks (8-12 volts) for at least 5 min via small stainless steel pin electrodes connected to a stimulator. The electrodes were implanted subdermally at the abdomen region to stimulate rapid movement (period of stimulation). Thereafter, oxygen consumption determinations were taken every minute during the maximal activity period (5 min). Then the snakes were left to rest for another 5 min (recovery period) where oxygen consumption were recorded each min. The data were expressed as ml O2/g body weight/ hr and corrected to STP.

Determination of total lactate production in resting and active states during anaerobic respiration

Total lactate production at temperatures ranging from 15°C to 35°C was determined in the whole body homogenates of resting and active snakes according to the method of Gatten (1985). The data were expressed as mg lactate/ g body wt. The total metabolic scope was calculated according to Bennett and Licht (1972) to determine the contribution level of each type of respiration following conversion to equivalent ATP millimoles at STP.

RESULTS

Resting and active oxygen consumption rate

Mean values of resting and active oxygen consumption (expressed as ml O2/g/hr) were observed to gradually increase with rising temperature from 15°c to 35°C in juvenile *Eryx jayakari (*Table 1). Also, the aerobic scope (ml O2/ g/hr) was increasing stepwise with the increased temperature. The differences in oxygen consumption between resting and active states were significant (Pd" 0.05) at any assigned temperature. The results showed that the highest Q10 values were obtained at 30°C - 35°C during resting and active states (3.4 and 2.5, respectively), however; the lowest value of Q10 (1.3) was recordrd at the range 25°C - 30°C in either active or resting state. Throughout aerobic scope, Q10 recorded the least value (0.84) at the temperature range 20°C - 25°C, whereas the highest value (2.7) was observed at 30°C - 35°C (Table 2).

Resting and active lactate production

Mean values of the whole body lactate concentration expressed as mg lactate per one gram body weight at different temperatures for resting and active juvenile *Eryx jayakari* are shown in Table 3 and Fig 1. There was a proportional relationship between elevated temperature and production of lactic acid either in resting or active snakes, however; the values were significantly (Pd" 0.05) different. Also, the anaerobic scope was found to be increased with the increased temperature up to 25°C - 30°C then it decreased at the range 30°C - 35°C. Concerning Q10 during

Table 1. Mean values ± S.E. of oxygen consumption and aerobic scope (ml O2/g/hr) during resting and active states of immature E. jayakari under different temperature zones.

Exp Temp °C	Mean of Oxygen consumption values (mlO2/g/hr)						
	No	XWt.(g)	Resting (VO_2)	No	XWt.(g)	Active (VO_2)*	Aerobic scope (mlO2/g/hr
15	5	5.56±0.58	0.037±0.011	5	6.04±0.9	0.142±0.034	0.105
20	5	5.56±0.58	0.051±0.011	5	6.04±0.9	0.218±0.028	0.167
25	5	5.56±0.58	0.094±0.031	5	6.04±0.9	0.282±0.029	0.188
30	5	5.56±0.58	0.124±0.021	5	6.04±0.9	0.342±0.027	0.218
35	5	5.56±0.58	0.22±0.032	5	6.04±0.9	0.548±0.093	0.328

*=$p<0.05$

Table 2. Thermal quotient (Q10) for oxygen consumption rate and aerobic scope during resting and active states in *E. jayakari*

Temperature interval(º C)	Resting Q_{10}	Active Q_{10}	Aerobic Scope
15-20	1.9	2.3	1.1
20-25	2.3	1.6	0.84
25-30	1.7	1.3	1.7
30-35	3.4	2.5	2.7
Overall Q_{10} (15-35 ºC)	2.4	1.6	1.4

anaerobic scope, it was the highest at 25°C - 30°C and the lowest at 30°C - 35°C (Table 4).

Total metabolic scope during outburst forced activity

There was a proportional increase in ATP molecules (μmoles/g/2min) during either aerobic or anaerobic respiration with the increase in ambient temperature. Also, the produced ATP during total metabolic scope (TMS) followed the same trend (Table 5 & Fig 2). The contribution of the aerobic scope in the TMS was decreasing with the increased temperature from 29% to 17% for 15°c and 30°c, respectively; then it increased again (21%) at 35°C. On the contrary, the contribution of the anaerobic scope in ATP production was increasing from 70.8% to 83% for 15°C and 30°C, respectively; it decreased slightly (79%) at 35°C (Table 5).

Table 3. Mean values ± S.E. of lactate concentration (mg /g body wt.) of the whole body of juvenile snake E. jayakari during resting and active states under different temperature zones.

Exp Temp °C	Mean of Lactate consumption values (mlO2/g/hr)						
	No	XWt.(g)	Resting	No	XWt.(g)	Active	Aerobic scope (mg/g)
15	2	4.95±0.15	0.087±0.004	2	6.57±0.62	0.288±0.005	0.201
20	2	7.15±0.65	0.092±0.004	2	5.4±0.9	0.385±0.025	0.288
25	2	4.8±0.6	0.125±0.005	2	5.3±0.85	0.51±0.05	0.390
30	2	5.8±0.6	0.18±0.01	2	6.4±0.9	0.775±0.045	0.610
35	2	4.85±0.25	0.211±0.009	2	5.4±0.81	0.90±0.015	0.695

Table 4. Thermal quotient (Q10) for lactate concentration during resting and active states and anaerobic scope of immature E. jayakari under different temperature ranges

Temperature interval(°C)	Resting Q_{10}	Active Q_{10}	Anaerobic Scope
15-20	1.1	1.4	1.5
20-25	1.7	1.8	1.8
25-30	2.25	2.2	2.4
30-35	1.2	1.4	1.2
Over all Q_{10} (15-35 °C)	1.5	1.6	1.7

DISCUSSION

A significant difference was found in oxygen consumption between resting and active states which agreed with the findings of Al-Otaibi

Table 5. Aerobic and anaerobic contribution in total metabolic scope within the first two minutes of forced stimulation in *E. jayakari*

Temp(°C)	Aerobic Scope ATP (µmoles/g/2min)	%	Anaerobic Scope ATP (µmoles/g/2min)	%	Total metabolic Scope ATP (µmoles/g/2min)
15	1.02	29.1	3.35	70.8	4.37
20	1.65	25.5	4.8	74.5	6.45
25	1.82	21.8	6.5	78.1	8.32
30	2.1	17	10.2	83	12.3
35	3.1	21	11.6	79	14.7

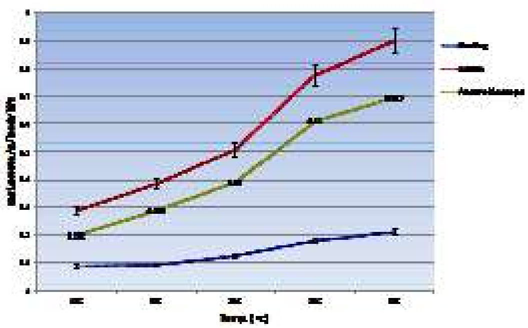

Fig. 1. Lactate concentration (mg /g body wt.) during resting and active states and anaerobic scope of immature *E. jayakari* under different temperatures.

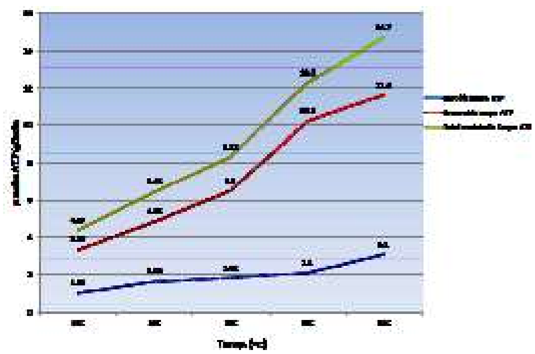

Fig. 2. Aerobic ATP, anaerobic ATP and total metabolic scope ATP in *E. jayakari* under different temperatures.

(2012) on *Eryx jayakari*, Rodiny (2006) on the lizard *D. zarudnyi* and Al-Farraj (1993) on the lizard *Scincus mitranus*. The calculation of Q10 revealed that the least value was obtained (1.3 and 1.7 for active and resting snakes, respectively) during the range of 20°C - 30°C which indicates that the oxygen consumption rate was almost constant throughout the temperature range closest to the preferred body temperature (PBT) in *Eryx jayakari* (28.6°C). Most of the previous studies showed that the value of Q10 would be minimal at the temperature range including PBT (Al-Johany and Al-Sadoon, 1996; Rodiny, 2006). The aerobic scope (0.218 ml O2/g/hr) recorded at 30°C (close to PBT) was very close to that (0.19 ml O2/g/hr) obtained by Rodiny (2006) using *D. zarudnyi* which shares the same habitat and nocturnal activity as *E. jayakari*. Lactic acid concentration was shown to be much greater in active *E. jayakari* when compared with rested snakes which could be attributed to the increased muscular activity that needs more energy. The anaerobic scope was much higher than the aerobic one in producing (ATP µmoles/g/2min) which was consistent with the findings of Al- Farraj (1993) and Rodiny (2006) and Al-Otaibi (2012). *E. jayakari* is known as a sand burrower, which means that it leads to a primarily anaerobic behavior where it depends mainly on lactic acid fermentation for energy production. Anaerobic respiration contributed with 70.8% and 82% at15°C and 30°C, respectively from the total amount of ATP produced which is in agreement with the results of Al-Sadoon (1986), Al- Farraj (1993) and Rodiny (2006). The Q10 for anaerobic metabolic scope for the snake, *E. jayakari* ranged from 1.2 to 2.4 which implicates its role during active state particularly, when temperature was less than PBT.

ACKNOWLEDGMENTS

The authors would like to express their sincere appreciation to the Deanship of Scientific Research at King Saud University, Riyadh, Saudi Arabia for funding this Research Group Project No. RGP-VPP-289.

REFERENCES

1. Al-Farraj, S.A. A Study on some ecological and physiological aspects of Scincus mitranus in Central Region of Saudi Arabia. M. Sc. Thesis, King Saud University. Saudi Arabia, 1993.
2. Al-Johany, A.M., Al-Sadoon, M.K. Selected body temperature and metabolic rate-temperature curves of three species of desert snakes. *Journal of Arid Environments,* 1993; **34**: 363-370.
3. Al-Otaibi, F.S. Ecological and Physiological Characteristics of the Sand Boa, Eryx jayakari in Riyadh Region of Saudi Arabia. M.Sc., Zoology Department, College of Science, King Saud University, Riyadh, Saudi Arabia, 2012.
4. Al-Sadoon, M.K. The role and the nature of the metabolic rate-temperature curves in lizards from different climatic regions. Ph.D. Thesis. Southampton University. U.K., 1983.
5. Al-Sadoon, M.K. Contribution of aerobic and anaerobic scope to the total metabolic scope of the desert skink Chalcides ocellatus (Forskal). *Comp. Biochem. Physiol*, 1986; 754-749.
6. Al-Sadoon, M.K. Survey of the reptilian fauna of the Kingdom of Saudi Arabia I The Snake Fauna of the Central Region. *J. King Saud Univ. Sc,* 1989; **1** (2):53-69.
7. Al-Sadoon, M.K. Metabolic rate-tempreraturе curves of the horned viper, Cerastes cerastes gasperetii, the moila snake, Malpolon moilensis, and the adder, Vipera berus. *Comp. Biochem. Physiol,* 1991; **99**(Al/2): 119-122.
8. Al-Sadoon, M.K., Spellerberg, I.F. Effect of temperature on the oxygen consumption of lizards from different climatic regions, *Amphibia-Reptilia,* 1985; **6**: 241-258.
9. AL-Shammeri, A.M. Ecological, ecophysiological and toxicological aspects of the pyramid viper, Echis pyramidum in Jazan province, Saudi Arabia. Ph.D. Dissertation, King Saud University, College of Science, Dept. of Zoology. Riyadh, Saudi Arabia, 2007.
10. Bennett, A.F., Licht, P. Anaerobic metabolism during activity in lizards. *J. Comp. physiol,* 1972; **81**:277-288.
11. Rodiny, H.A. Ecological and Ecophysiological Aspects of Worm Lizard, Diplometopon zarudnyi in Al-Riyadh Region of Saudi Arabia. *M.Sc. thesis*, King Saud University, College of Science, Department of Zoology, Riyadh, Saudi Arabia, 2006.