

ABSTRACTS

THE CONSEQUENCES OF AN EXTREMELY LOW METABOLIC RATE ON
ACTIVITY PATTERNS IN THE DESERT GRASSLAND SCORPION,
Paruroctonus utahensis.

Richard A. Bradley, Zoology Department, University Sydney.

The desert grassland scorpion *Paruroctonus utahensis* lives in a high-altitude shortgrass prairie in central New Mexico USA. This area is characterized by a short growing season with low and variable precipitation. This scorpion has an extremely low resting metabolic rate ($55 \text{ ul O}_2 \text{ g}^{-1} \text{ h}^{-1}$ @ 20°C). The activity patterns of this species are low and irregular. Individuals can maintain a positive annual energy balance on as few as 2 or 3 large meals/yr. Some ecological consequences of this are that the species is relatively long lived with irregular iteroparous reproduction. The "conservative" life style of this species is evidently a response to selection for reduced risk of being preyed upon as well as to irregular annual productivity.

EFFECTS OF BODY TEMPERATURE, MASS AND ACTIVITY ON AEROBIC
AND ANAEROBIC METABOLISM IN JUVENILE *Crocodylus*
porosus.

Jon Wright, Zoology Department, University of Sydney.

Resting ($\text{VO}_2 \text{ rest}$) and maximal ($\text{VO}_2 \text{ max}$) oxygen consumption of juvenile *Crocodylus porosus* increased significantly with body temperature (T_b) and had mass exponents of 0.702 ± 0.16 and 0.85 ± 0.53 (mean \pm 95% c.l.) respectively. Compared to other reptiles, $\text{VO}_2 \text{ max}$ of *C. porosus* was low. Both $\text{VO}_2 \text{ rest}$ and $\text{VO}_2 \text{ max}$ had high thermal sensitivities (Q_{10}) and reached peak levels within the T_b range 30 to 33 C which overlaps preferred body temperature range and summer water temperatures. This may enable crocodiles to be most active and to recover rapidly from activity within a narrow T_b range experienced throughout the day in the field. Anaerobic capacity showed no significant trend with changes in body mass (M) or T_b . During activity to exhaustion, aerobic capacity increased in T_b , while anaerobic capacity remained thermally independent. Consequently, the total metabolic input and proportion of energy supplied aerobically increased with each increase in T_b to a maximum at 33 C and may explain the increased duration of activity at higher T_b 's.

THE MEASUREMENT OF ENERGY USAGE IN FREE-RANGING KANGAROOS AND SHEEP

F.D. Fanning and T.J. Dawson, School of Zoology, University of N.S.W.

What are the energetic costs of being a kangaroo in the semi-arid environment of Australia. Would it be cheaper to be a sheep?

In order to achieve some understanding of the "energetics of existence", we have been attempting to measure the levels of energy use in free-ranging sheep and kangaroos at our research facility at Fowlers Gap. Our requirement is for a relatively inexpensive technique, which would enable the monitoring of a number of animals and would be reliable, repeatable and field modifiable.

Various techniques are currently available for the estimation of energy usage in the field, including doubly-labelled water, nitrogen turnover measurements and others. These generally involve a few, widely spaced samples from the animals and necessitate integration over periods ranging from a day to weeks. The technique we have been using and developing involves a correlation between heart rate and oxygen consumption combined with observations on behaviour, to develop an energy usage/activity profile of several animals at frequent intervals over several weeks.

THE ENERGETICS OF THE LITTLE PENGUIN: WALKING, SWIMMING AND KEEPING WARM.

R.V. Baudinette, School of Biological Sciences, Flinders University.

Measurements of body temperature and metabolic rate show that the little penguin *Eudyptula minor* is at the lower end of the typical avian range of both parameters. Uncertain food supplies and rough weather preventing feeding may correlate with an apparent low metabolic rate.

Heat production is augmented by shivering at ambient temperatures below 20°C and the calorogenic effect of feeding produces a doubling of metabolism. Moulting results in a 40 per cent increase in metabolism.

From treadmill experiments, the minimal mass specific energy usage for walking is at the upper range of locomotory costs seen for mammals and birds. In water, penguins move with lower locomotory costs than any other swimming endotherm for which data are available. Subsurface swimming results in a further reduction.

References

- Baudinette, R.V. and P. Gill (1985). *J. Comp. Physiol.* 155, 373-380.
 Baudinette, R.V. et al. (1986). *Aust. J. Zool.* 34, (in press).

VENTILATORY ADAPTATIONS FOR DIVING IN LITTLE PENGUINS

C.D. Stahel and S.C. Nicol, Dept. of Physiology, University of Tasmania.

Little information is available on the possible ventilatory adaptations for diving in penguins. Comparison of ventilation in a plethysmograph and ventilation measured directly by pneumotachography with a light-weight Fleisch tube and mask gave identical results. Use of a mask, however, resulted in significant hyperpnea compared to unrestrained conditions.

Ventilation and oxygen consumption were measured in a plethysmograph across a range of air and water temperatures. Ventilation in non-heat stressed penguins remained closely related to oxygen consumption with a very high oxygen extraction coefficient of 51.9%. This high gas exchange efficiency is suggested to be linked with characteristic short aerobic dives.

POUCH OXYGEN LEVELS IN THE TAMMAR WALLABY AND RESPIRATORY FUNCTIONS OF JOEY BLOOD

R.V. Baudinette, B.J. Gannon, School of Biological Sciences and Medicine, Flinders University.

An examination of oxygen affinity during development in the tamar wallaby, *Macropus eugenii*, has shown that the haemoglobin P_{50} varies from about 40 torr in 10 day old joeys to lower values of between 25-28 torr at 80-110 days in age. After this time P_{50} increases with body mass up to the adult value of 29-30 torr. Iso-electric focussing has revealed only one haemoglobin present during this 170 day period.

Pouch O_2 levels also vary throughout the development period, with the greatest difference between pouch and ambient air occurring at around 110 days.

We suggest that an organic phosphate is modulating the properties of haemoglobin to provide matching with pouch oxygen levels.

THE VASCULAR ANATOMY AND INNERVATION OF THE GILLS OF *Octopus australis*.

B.K. Evans and P. Darling, Department of Zoology, University of Melbourne.

Scanning electron microscopy of vascular casts and critical-point dried gills of *O. australis* produced no evidence of branchial shunts, discrete low resistance pathways which would allow blood to bypass the gas exchange surface. The complex vascular organisation of this surface includes capillaries and "lamellae" where the direction of blood flow bears no uniform relationship to the direction of water flow through the gills. Silver staining showed the vascular smooth muscle, extrinsic muscle and epithelium of the gills to be well innervated. Immuno-histochemistry, H.P.L.C., and *in vitro* pharmacology suggest that at least

part of this innervation is serotonergic and that nerve-mediated regulation of flow within the gill may occur.

THE LUNGS OF THE SOLDIER CRAB, *Mictyris longicarpus*

C.A. Farrelly and P. Greenaway, School of Zoology, University of N.S.W.

Mictyris has the most complex lung yet described for a brachyuran. The lining of the branchiostegite is extensively vascularised, as in other air-breathing crabs, but additionally is penetrated by numerous blind ending pores ca. 1mm deep which give the lung a spongy appearance. The surface area for gas exchange is further enhanced by the presence of an epibranchial fold, an outgrowth from the roof of the branchiostegite. This too is spongy in appearance and divides the lung into two compartments. The inner of these is a channel carrying water for the feeding process whilst the outer is air-filled and is believed to function in gas exchange. The morphology, ultrastructure and vasculature will be described.

FUNCTIONAL MORPHOLOGY OF THE CEPHALIC VASCULATURE IN THE TASMANIAN DEVIL *Sarcophilus harrisii* (Marsupialia : Dasyuridae)

S.K.H. Shah and S.C. Nicol, Departments of Physiology and Anatomy, University of Tasmania.

Anatomical examination of the cranial vascular systems of the Tasmanian devil, using angiography, polyester resin casts and dissections demonstrated a convoluted and tortuous region of the carotid artery situated within the cavernous sinus.

This "Arteria tortuosa", a unique vascular structure, appears to be functionally analogous to the cephalic heat exchanging system: the carotid rete of panting eutherians. Preliminary physiological data supports this view as 'uncoupling' of brain and body temperatures has been recorded.

The Arteria tortuosa is also of comparative interest as it is not present in all marsupials. The pattern of the Circle of Willis (and hemodynamics?) differs from that reported for any eutherian.

THE AUTONOMIC CONTROL OF CIRCULATION IN THE EEL *Anguilla australis*

M.F. Capra, Pharmacology & Nutrition, Q.I.T.

The vascular responses to gross sympathetic stimulation were observed in curarised, saline perfused eel preparations. Electrical stimulation of the sympathetic outflow produced a stimulation. Bolus injections of adrenaline and noradrenaline elicited similar vasoconstrictor responses. The vasoconstrictor response to

stimulation was blocked by phentolamine but unaffected by propranolol.

The neurone blocking drug bretylium abolished the response to electrical stimulation. Ganglionic blockade with pentolinium or curare also abolished the vasoconstrictor response to electrical stimulation. Vascular control in the eel has a nervous component involving an alpha mediated vasoconstriction. Selected veins and arteries when examined by fluorescent histochemistry provided anatomical support for adrenergic control.

PULMONARY HEMODYNAMICS AND LUNG FLUID BALANCE FOLLOWING PULMOCUTANEOUS BARORECEPTOR DENERVATION IN THE TOAD, *Bufo marinus*.

Smits, A.W., W.W. Burggren, N.H. West*. University of Massachusetts, Amherst, MA. (USA), and University of Saskatchewan, Saskatoon, Saskatchewan (Canada)*.

Pulmonary hemodynamics and net transcapillary fluid flux were measured in conscious toads before and following bilateral denervation of the pulmocutaneous arterial baroreceptors by severing the recurrent laryngeal nerves. Denervation evoked 3-4 fold increases in pulmonary blood flow (50 to 175 ml/kg.min), a doubling of hydrostatic driving pressure (20 to 37 mmHg) and a 10-fold increase in transcapillary fluid filtration out of the lung microvasculature (0.74 to 7.77 ml/kg.min). Our analyses of pulmonary hemodynamics and the associated microvascular filtration following denervation suggest that pulmocutaneous baroreceptors may function largely to protect the lung from edema induced by transient elevations in blood pressure and flow.

COMPARATIVE WATER METABOLISM OF RED AND EASTERN GREY KANGAROOS

H.C.K. McCarron, R. Buffenstein & T.J. Dawson, School of Zoology, University of N.S.W.

The Eastern Grey Kangaroo (*Macropus giganteus*) is widely distributed throughout the eastern states. Although regarded as having evolved for life in a woodland-type habitat, the range of this species extends into the arid zone where it may be considered a marginal occupant. Its limited and fluctuating distribution in the arid zone suggests that the species may not be as well adapted physiologically to cope with desert conditions as the arid-adapted Red Kangaroo (*Macropus rufus*). In the present study this possibility was investigated in terms of their water metabolism.

Using the tritiated water technique it was found that, during summer, with water available *ad libitum*, *M. giganteus* had a 34% higher water requirement than *M.*

rufus. During a subsequent period of 14 days water restriction the water turnover of *M. giganteus* decreased by 74% and by 50% in *M. rufus*. This indicates that the latter was the least water stressed of the two species. *M. rufus* was also able to rehydrate more rapidly than *M. giganteus*.

The data collected suggest that in terms of water metabolism, *M. rufus* would be better able to cope with desert conditions than would *M. giganteus*.

OSMOTIC FRAGILITY OF RED BLOOD CELLS IN FREE-RANGING AND CAPTIVE KANGAROOS

R. Buffenstein, H.C.K. McCarron & T.J. Dawson, School of Zoology, University of N.S.W.

Lack of water may influence the eco-physiology of animals inhabiting arid-zones. Animals most suited to arid areas would be those that tolerate periods of dehydration and that rehydrate rapidly without adverse effects. Rapid dehydration may result in the lysis of red blood cells (r.b.c.) and subsequent death from haemoglobinuria. This can be prevented by a) controlling water flux across the rumen (e.g. Bedouin goat) or b) by having erythrocytes that are resistant to changes in osmotic pressure (e.g. camel). Osmotic fragility of the r.b.c. was measured in sheep and kangaroos free-ranging in the arid zone and in kangaroos held in captivity. The r.b.c. of 4 species of free-ranging kangaroos showed similar resistances to changes in osmotic pressure. This resistance was much higher than that shown by sheep. The captive kangaroos were found to have an even higher resistance to osmotic changes than their free-ranging counterparts. This paradoxical finding is discussed and may be a consequence of nutritional factors.

CALCIUM STORAGE AND MOULTING IN *Holthuisana transversa* A FRESHWATER/LAND CRAB

P. Greenaway, S. Sparkes & C.A. Farrelly, School of Zoology, University of N.S.W.

Most aquatic, decapod crustaceans lose almost all their body calcium during ecdysis. Calcium required to calcify the new exoskeleton is then absorbed from the water in which they live during early postmoult. *Holthuisana transversa*, however, retains about 65% of its body calcium through the moult, resorbing it from the old exoskeleton and storing it in the blood as small granules. This raises blood total calcium concentrations to $>2 \text{ mol L}^{-1}$ in late premoult. Ultrastructural studies reveal that granules are formed intracellularly by the cuticle secreting cells of the epidermis. The estimated rate of production of granules is $45 \times 10^6 \text{ g}^{-1} \text{ s}^{-1}$. Breakdown of the granules occurs in the same cells during postmoult and is an even more rapid process. As *Holthuisana transversa* lives in temporary waters the high retention of body calcium is probably

necessary to reduce the period needed for absorption of calcium from often short-lived water bodies.

MANDIBULAR SALIVA OF THE RED KANGAROO

A.M. Beal, School of Zoology, University of N.S.W.

Because of the episodic nature of thermoregulatory licking, the saliva used for this purpose must come mainly from the large paired glands viz parotid and/or mandibular glands. Since parotid saliva is poorly adapted for use as a coolant, the effect of flow rate and mineralocorticoid administration on the composition of mandibular saliva was investigated. Kangaroo mandibular saliva was found to be composed mainly of Na, K and Cl and to contain low HCO_3^- and PO_4 concentrations. The levels of potassium and phosphate found were dissimilar to those previously reported for saliva from this gland. Unlike the parotid gland, the mandibular glands respond to acute elevation of plasma aldosterone levels but its response to chronic mineralocorticoid administration was relatively poor and was associated with little hypertrophy of the intralobular ducts. Consequently mandibular saliva is better suited for use as a coolant than parotid saliva.

PHYSIOLOGICAL DEVELOPMENT OF THE TAMMAR WALLABY (*Macropus eugenii*): THYROID HORMONES AND ORGAN GROWTH

A.J. Hulbert & P.A. Janssens, Department of Biology, University of Wollongong and Department of Zoology, Australian National University.

Plasma and tissue samples (liver, kidney, heart and brain) were collected from pouch young of the Tamar wallaby (*Macropus eugenii*) ranging in age from 10 days to 220 days old.

Plasma concentrations of thyroxine were at adult levels even in very young pouch young. At about the time of the development of endothermy plasma thyroxine rose to concentrations about 6 times the adult level and then fell to adult concentrations. Triiodothyronine concentration was low to begin with and rose to adult levels at about the time of exit from the pouch (approx. 200 days).

The body organs grew in an allometric fashion with the kidney and brain showing a change in allometric growth at around 120 days of age. Liver and heart however, showed the same allometric growth up to 200 days of age.

PINEAL AND PITUITARY REGULATION OF SEASONAL BREEDING IN THE TAMMAR WALLABY

C.H. Tyndale-Biscoe, L.A. Hinds & S.J. McConnell, CSIRO Division of Wildlife & Rangelands Research.

From the winter to the summer solstice the Tamar is in seasonal quiescence. During this time an artificial photoregimen (15L:9D changing to 12L:12D), which mimics in

an exaggerated way the changes after the summer solstice, is followed by (1) an immediate increase in the duration of elevated melatonin secreted by the pineal gland, (2) abolition of a morning pulse of prolactin from the pituitary gland by day 5, (3) a pulse of progesterone from the reactivated corpus luteum on day 10, and (4) birth on day 32. The causal relationships between these events will be discussed, particularly the way in which the changes in the melatonin profile may be read as a message in the hypothalamus and lead to the subsequent sequence of events.

PLASMA PROGESTERONE AND OESTRADIOL DURING THE PERIPARTUM PERIOD IN THE TAMMAR, *Macropus eugenii*.

Lyn A. Hinds. Division of Wildlife & Rangelands Research, CSIRO.

This study has examined the relationships between plasma progesterone, oestradiol and luteinising hormone (LH) during late pregnancy, parturition, post-partum oestrus and ovulation. Coincident with parturition there is a rapid decrease in plasma progesterone, followed 8.3h later by a rise in oestrogen and behavioural oestrus. The pre-ovulatory LH surge, which is dependent on the oestrogen rise, follows it by 7h. Ovulation occurs 30h after mating and 24h after the LH surge. In late pregnancy progesterone is produced by the corpus luteum while the source of the post-partum rise in oestrogen is the Graafian follicle.

STEROID HORMONES IN THE AUSTRALIAN LUNGFISH, *Neoceratodus forsteri*.

Jean M.P. Joss, School of Biological Sciences, Macquarie University.

Neoceratodus is the oldest of the three living genera of dipnoans, having changed very little since the late Devonian/early Carboniferous. Current research places it closer to the ancestral amphibians than either *Protopterus* and *Lepidosiren* or the coelocanth, *Latimeria*. As such it is of unique interest to comparative endocrinology. Very little is known, however of any aspect of its endocrinology. This is probably at least partly due to its restricted occurrence and its total protection. This presentation will describe some initial studies on the steroid hormones in *Neoceratodus forsteri*.

Animals were netted in the Mary River system in September, 1984, January and May, 1985. Blood samples were collected by heart puncture and animals tagged and returned to the river. In May 2 live animals were taken back to the laboratory. These were used for gonad incubation experiments designed to examine steroid metabolism. The plasma samples were used for HPLC and TLC separation and identification of steroid hormones and for RIA of progesterone, estradiol-17beta, estriol and estrone.

PRELIMINARY ESTIMATES OF THE INDIVIDUAL AND MATERNAL COMPONENTS OF THE SELECTION RESPONSE IN THE TRANGIE ANGUS SELECTION LINES.

Robert Herd, Agricultural Research Centre, Trangie.

Crossmothering between selection lines was employed to evaluate the individual and maternal components of the response to selection for weight gain in beef cattle. Selection is based on average daily gain from birth to one year of age and there presently exists a 20% divergence in growth rate between the high-line and the low-line. The crossmothering technique employed has a high success rate and does not itself appear to affect the subsequent growth of calves. Crossmothering of female calves between selection lines in 1984 indicated that the maternal component of the selection response is very small and the individual component very large. The experiment is being repeated in 1985.

SURVIVAL OF ENDOTHERMS AT LOW BODY TEMPERATURE - RESTRICTIONS IMPOSED BY MEMBRANE STRUCTURE AND FUNCTION.

M.L. Augée & J.K. Raison, School of Zoology, University of New South Wales and CSIRO Plant Physiology Group.

Several lines of evidence indicate that survival of endotherms at low body temperature requires adjustments in membrane thermal response. Mammalian hibernators make adjustments in membrane thermal response of liver, kidney and brown fat tissue prior to actually experiencing the low body temperatures of natural torpor. Heart and nervous tissue however appear to maintain a constant thermal response throughout the annual cycle and for these tissues the thermal response is typical of ectotherms.

THERMAL AND WATER RELATIONS OF EGG INCUBATION BY EMUS.

William A. Buttemer, Lee B. Astheimer, and Terence J. Dawson, School of Zoology, University of New South Wales.

The incubation period of emus (*Dromaius novaehollandiae*) lasts about eight weeks, during which time the incubating male is presumed to neither eat nor drink. Although there has been suggestion that incubating emus conserve energy through reduced thermoregulatory expenditure, the extent to which this occurs will be limited by the thermal requirements for successful embryo development. We have just completed a study of the incubation cycle for two emus. The topics to be discussed are:

- a- body temperature and heart rate of incubating males
- b- egg temperature, egg water loss, and nest humidity
- c- thermal sensitivity of emu embryos.

EFFECT OF TEMPERATURE ON HATCHABILITY AND ENERGETIC COST OF DEVELOPMENT IN EGGS OF MALLEEFOWL *Leipoa ocellata*

David T. Booth, Department of Zoology, University of Adelaide.

Measurement of incubation temperatures in natural Malleefowl incubation mounds showed that eggs can experience a relatively wide range of temperatures (28-38°C) over the incubation period. Malleefowl eggs were incubated artificially at temperatures of 30, 32, 34, 36 and 38°C and oxygen consumption of developing eggs measured throughout incubation to see if incubation temperature affects hatchability and development costs. No eggs hatched at 30°C, 22% hatched at 32°C, 80% at 34°C, 44% at 36°C and 32% at 38°C. Total oxygen consumption over the incubation period was temperature dependent, requiring 158 mlO₂.g⁻¹ at 32°C. The larger amounts of oxygen consumed at lower temperatures results from both longer incubation periods and higher peak rates of oxygen uptake.

EGG FORMATION IN SEABIRDS

L. Astheimer, School of Zoology, University of New South Wales.

The timing of egg formation and rates of yolk deposition were investigated in 30 species of seabirds from four avian orders: Sphenisciformes, Procellariiformes, Pelicaniformes and Charadriiformes. The chronology of egg formation is usually uniform within a species, but varies markedly interspecifically. Factors such as egg size, clutch size, laying interval (time between ovipositions), and presence of lag period (time between yolk completion and laying) may contribute to this variability. Patterns of egg formation will be discussed in relation to their phylogenetic and ecological correlates.

THE EFFECTS OF CIGUATOXIN ON NERVE FUNCTION IN TELEOST FISH.

A.E. Flowers and M.F. Capra, Pharmacology & Nutrition, Q.I.T.

Ciguatoxin (CTX) is a powerful nerve poison found in the flesh of certain reef fish. In mammals CTX affects several nerve conduction parameters in a manner that suggests the toxin acts on Na⁺ channels to prolong their opening time.

The effects of CTX on fish nerves have not been previously observed. Fish carrying CTX show no observable pathology. Data will be presented on the effects of CTX on nerve conduction in two groups of fish:- (i) "non-carrier" species that never have the toxin in their flesh and (ii) "carrier" species that may carry CTX in their flesh.

The results of ²²Na⁺ efflux experiments from the olfactory nerves of "carrier" and "non-carrier" species will also be presented.