

HULBERT

**EIGHTH MEETING
OF
COMPARATIVE
PHYSIOLOGISTS**

December 7-8th 1991

**PROGRAM
AND
ABSTRACTS**

Mary White College
University of New England

Organiser: J.R. Roberts.

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**EIGHTH
COMPARATIVE PHYSIOLOGY MEETING
DECEMBER 7-8, 1991**

Marnie Yeates Room, Mary White College, University of New England

PROGRAM

Saturday December 7

08.00 - 08.50 Registration
08.50 - 09.00 Preliminaries

Session 1: ENERGETICS

Time	Title	Author
09.00	Three Australian bats: their micro-habitats, energy and water balance, and status.	Russell Baudinette S. Churchill K. Christian J. Nelson P. Hudson
09.20	Thermoregulation and metabolism in Gould's long-eared bat, <i>Nyctophilus gouldi</i> .	Alison Curtin M. Thompson S. Morris
09.40	Aquatic oxygen uptake of a freshwater turtle, <i>Elseya sp.</i>	Peter King
10.00	Comparative energetics of four species of Varanid lizards.	Keith Christian
10.20	Effect of corticosterone on avian resting metabolic rates.	Bill Buttemer L.B. Astheimer J.C. Wingfield
10.40	MORNING TEA (Lunches and Teas are provided to registrants)	

Session 2: BLOOD

Time	Title	Author
11.10	Blood viscosity in penguins.	Stewart Nicol Judy McNeall
11.30	Glutathione levels and oxidant defense in sheep erythrocytes.	Nihal Agar Y. Maede & I. Goto.
11.50	Erythrocyte metabolism in diving (<i>Tursiops truncatus</i>) and flying (<i>Miniopterus schreibersii</i> , <i>Pteropus scapulatus</i>) mammals.	Ian Godwin N.S. Agar G.A. Chaffey
12.10	Oxygen carriage in blood of neonates and adults of the brushtail possum (<i>Trichosurus vulpecula</i>).	Robert Holland S.J. Calvert R.T. Gemmell

12.30 Blood oxygen carriage and change in hemoglobin during early development of the Tammar wallaby (*Macropus eugenii*). Susan Calvert
R.A.B. Holland
L.A. Hinds

12.50 **LUNCH**

Session 3: NEUROPHYSIOLOGY/ OSMOREGULATION

Time	Title	Author
02.00	Inhibition of cardiac vagal action by galanin but not neuropeptide Y in the brush-tailed possum, <i>Trichosurus vulpecula</i> .	Gillian Courtice E.K. Potter D.I. McCloskey
02.20	Cardiac responses attributed to somatostatin are diminished by repetitive stimulation of cardiac vagal nerves in the toad.	Elaine Preston G. Courtice
02.40	Adrenergic receptors in non-mammalian vertebrates.	Peter Janssens Jenny Grigg
03.00	Osmoregulation and ammonia excretion in the crab <i>Geograpsus grayi</i> .	Glenn Varley P. Greenaway
03.20	Responses to dehydration in green tree frogs (<i>Littoria caerulea</i>) and cane toads (<i>Bufo marinus</i>).	Julie Roberts M. Warburg H. Heatwole
03.40	Colonic absorption and nasal gland development in relation to NaCl intake in the ostrich (<i>Struthio camelus</i>).	E. Skadhauge

04.00 **AFTERNOON TEA**

Session 4: ENERGETICS

Time	Title	Author
04.30	Respiratory, ion and acid-base regulation in the amphibious crab, <i>Leptograpsus variegatus</i> .	Steve Morris Tania Edwards
04.50	Membrane fatty acids and adaptations to the environment.	Tony Hulbert P. Couture K. Withers P.A. Janssens
05.10	Thermal physiology of the scorpion <i>Urodacus manicatus</i> .	Chris Holden
05.30	Maintenance energy and nitrogen requirements of the magpie goose, <i>Anseranas semipalmata</i> .	Adam McLean T.J. Dawson F.D. Fanning P. Whitehead
07.00	CONFERENCE DINNER	Mary White College.

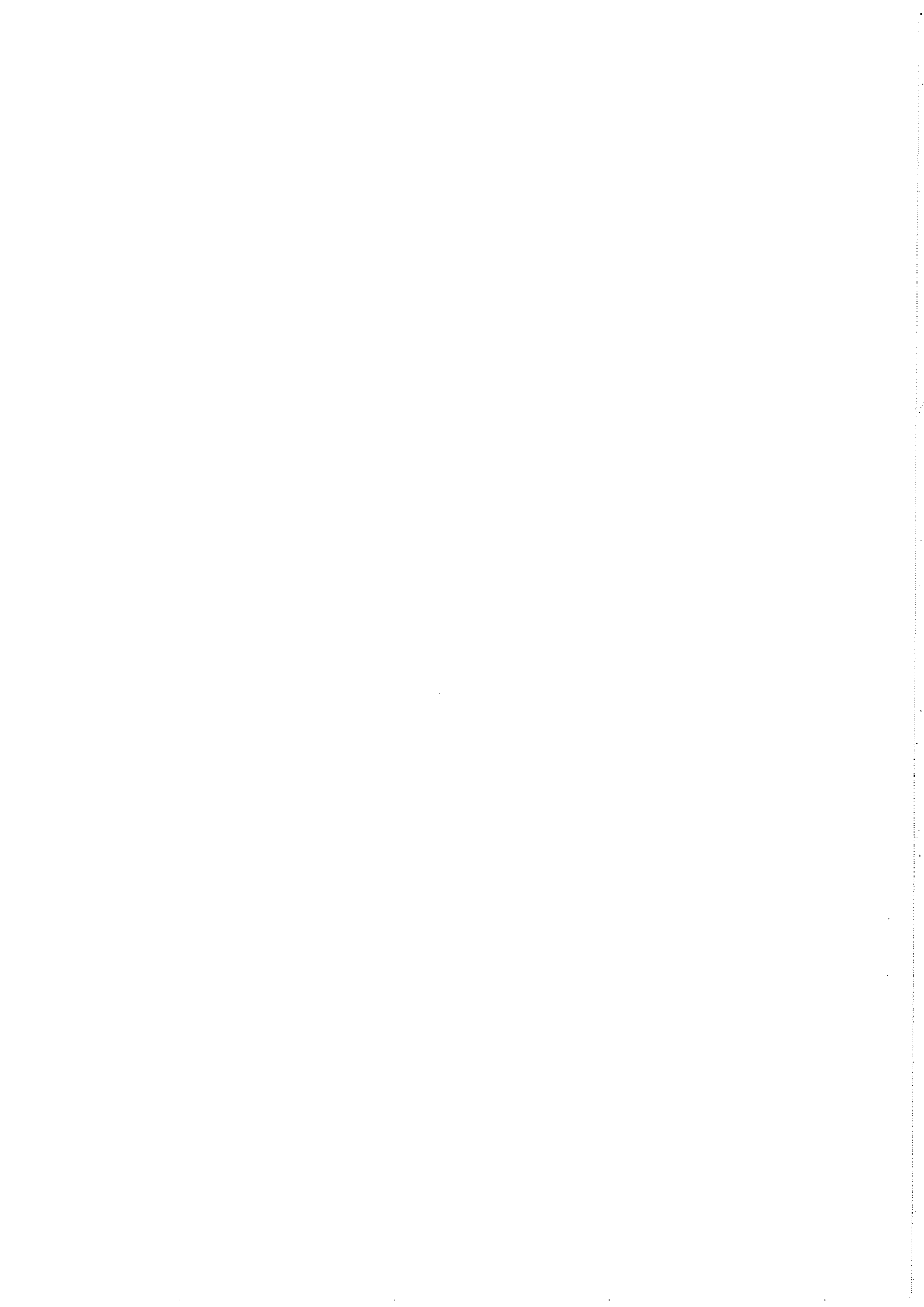
Sunday December 8

Session 5: ENDOCRINE/ REPRODUCTION/ DIGESTION

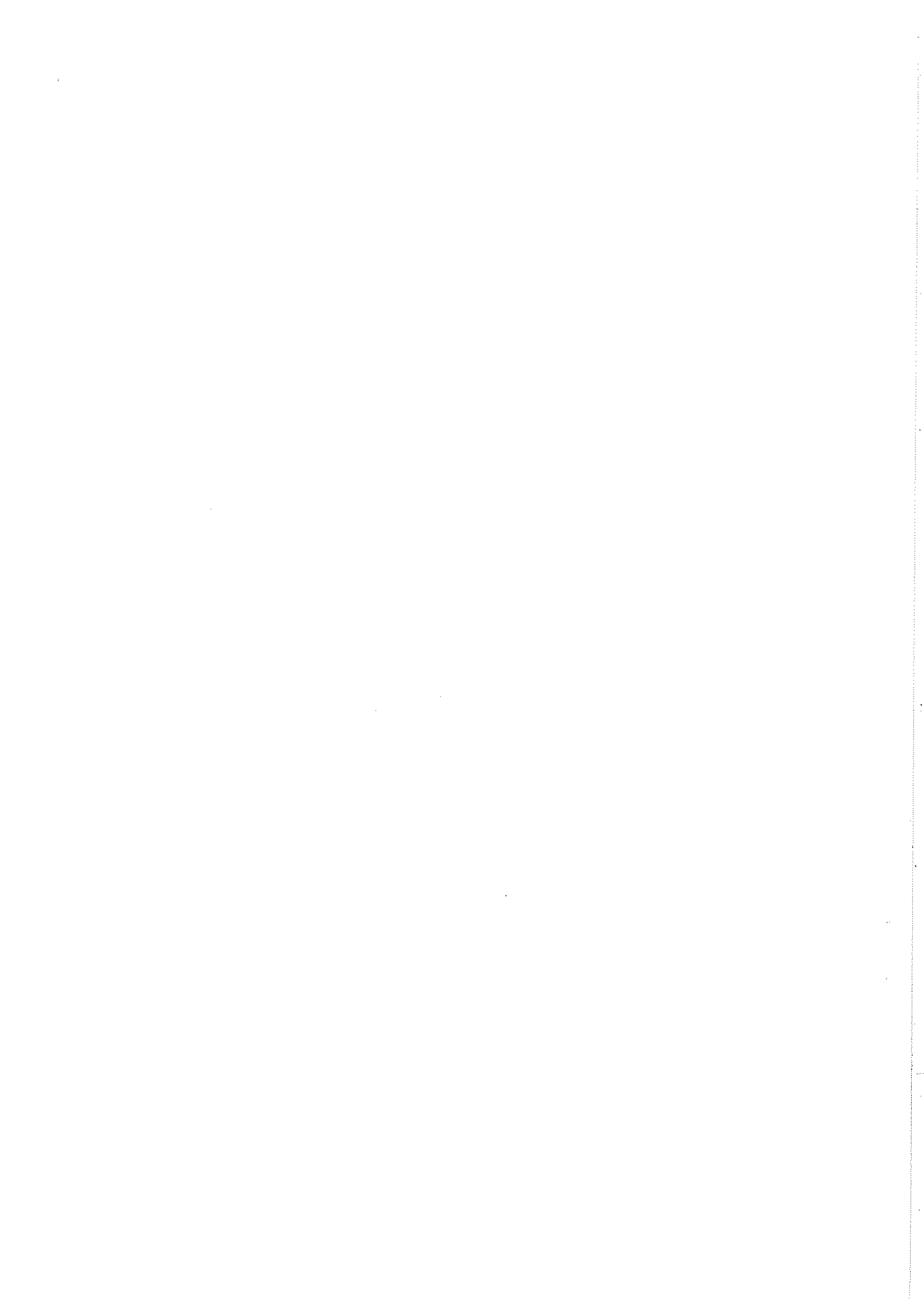
Time	Title	Author
09.00	Prostaglandin F2 α and the control of reproduction in the Tasmanian bettong, <i>Bettongia gaimardi</i> .	Randy Rose A.S. MacFadyen S.M. Jones
09.20	Transfer of thyroxine in the milk of two marsupials, the northern brown bandicoot, <i>Isoodon macrourus</i> and the brushtail possum, <i>Trichosurus vulpecula</i> .	Robert Gemmell C. Sernia
09.40	Gender and seasonal differences in adrenal response to ACTH challenge in an arctic-nesting passerine.	Lee Astheimer W.A. Buttemer J.C. Wingfield
10.00	Acidosis in folivorous marsupials.	Bill Foley
10.20	Digestive function in some North American rodents.	Ian Hume G.J. Kenagy K.R. Morgan
10.40	Parotid salivation in Potoroine marsupials.	Michele Beale
11.00	MORNING TEA	

Session 6: ENERGETICS

Time	Title	Author
11.30	Locomotion in small Macropodids.	Matthew McCloskey T.J. Dawson
11.50	Influence of body size on the respiratory responses to increasing metabolism in Dasyurid marsupials.	Terry Dawson M.A. Chappell J.F. Hallam
12.10	Metabolism and ventilation during acute hypoxia in adult mammals: a comparative analysis in small species.	Peter Frappell C. Lanthier R.V. Baudinette J.P. Mortola
12.30	Lactation and energetics in the koala.	Andrew Krockenberger I.D. Hume S.J. Cork
12.50	CONCLUDING COMMENTS INCLUDING THE LOCATION OF THE MEETING IN 1992	
01.00	LUNCH	



ABSTRACTS



GLUTATHIONE LEVELS AND OXIDANT DEFENSE IN SHEEP ERYTHROCYTES

N.S. Agar*, Y. Maede** and I. Goto**

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**Department of Veterinary Internal Medicine, Hokkaido University, Sapporo, Japan

Erythrocyte glutathione (GSH) is generally thought to protect haemoglobin and membrane components from oxidative damage. Canine red cells with hereditary high concentrations of GSH (about 5-7 times that of normal) show increased protection against oxidative damage induced by acetylphenylhydrazine (APH), a strong oxidant drug, as compared with normal cells¹. However, Eaton *et al.*² reported that human red cells artificially depleted of glutathione show normal resistance to oxidant challenge. Thus, the aim of this project was to clarify these discrepancies concerning the oxidant defense functions of GSH in erythrocytes, using normal and low-GSH sheep.

Blood was collected from 20 adult Merinos (11 normal and 9 low GSH). Erythrocytes were washed with saline and suspended in an isotonic phosphate buffer at a haematocrit of about 10% and incubated with 6 mM APH at 37°C. Aliquots of the suspensions were withdrawn for analysis of GSH, methaemoglobin and Heinz bodies.

The main findings were (i) the formation of Heinz bodies in low-GSH cells was significantly higher than that in normal-GSH cells and (ii) there was a high negative correlation between Heinz body formation and the level of GSH in sheep red cells exposed to APH.

1. Maede Y. *et al.* Blood, 73: 312-317, 1989
2. Eaton, J.W. *et al.* Prog. Clin. Biol. Res., 319: 23-38, 1989

Gender and seasonal differences in adrenal response to ACTH challenge in an arctic-nesting passerine

L. B. Astheimer, W. A. Buttemer and J. C. Wingfield

Department of Zoology, University of Washington, Seattle, Washington, U.S.A.

(Present address of LBA: Dept. of Anatomy, University of Tasmania, Hobart; present address of WAB: Dept. of Physiology, University of Tasmania, Hobart)

We used a standardized protocol to evaluate adrenal response to stress in free-living white-crowned sparrows (*Zonotrichia leucophrys gambelii*) in which five serial blood samples (50-100µl) were taken for plasma corticosterone (B) measurement over the course of an hour of captivity (at 1, 5, 10, 30 and 60 min). We observed gender differences in adrenal responsiveness, with male plasma B levels rising 2 to 4 times higher than those of females under capture stress during the breeding season, but not during winter. To investigate the basis of this difference, we injected ACTH (0.02 I.U./g in 10 µl saline) or saline (control) to breeding and non-breeding male and female sparrows and evaluated B levels over a 2 h post-injection period. All birds were pre-treated with dexamethasone implants to suppress endogenous ACTH secretion. ACTH injections resulted in an elevated adrenal response in both genders, with non-breeding B profiles consistently lower than those of breeding birds. Dexamethasone pretreatment effectively suppressed B in all groups *except* in breeding males, which showed no B suppression. This apparent lack of glucocorticoid feedback in breeding males may be correlated with an uncoupling of adrenal effects on reproductive function which has been noted in other arctic passerines.

**THREE AUSTRALIAN BATS: THEIR MICROHABITATS, ENERGY AND
WATER BALANCE, AND STATUS.**

R.V. Baudinette, Sue Churchill, Keith Christian, John Nelson
and Peter Hudson

Biological Sciences, Flinders University
Biology, University of the Northern Territory, Darwin
Population and Evolutionary Biology, Monash University

The orange horseshoe bat and the ghost bat are both regarded as rare and vulnerable and recent surveys show few active roosting sites. In contrast, a bat of similar mass to the former species, the common bent-wing, has a range among the largest for any terrestrial mammal. This paper reports on the microclimatic conditions of the three species and relates these two aspects of energy and water balance. We determine the ambient temperature and humidity at which evaporative water loss and metabolic water production are equal and relate this lumped parameter to roost conditions. We conclude that a **combination** of conditions is required by the horseshoe bat and this may account for its restricted range. For the ghost bat, other factors such as food supply may play a role in its decline. The bent-wing bat is a "flying rodent" in regard to its metabolism-linked water balance.

PAROTID SALIVATION IN POTOROINE MARSUPIALS

A.M.Beal, School of Biological Science, Univ of N.S.W.

Based on diet and limited physiological/morphological data for one species of *Bettongia*, it has been argued that Potoroid marsupials possessed a highly-active fermentation in the fore-stomach. The presence of large parotid glands was cited as evidence that these animals needed large volumes of highly-buffered saliva to control pH in the ferment. I have investigated the composition of cholinergic parotid saliva from two species of rat-kangaroo, *Aepyprymnus rufescens* and *Potorous tridactylus*. Each animal was anaesthetized, lateral tail vein cannulated, salivary duct catheterized and flow stimulated with carbachol or bethanachol infusion. In both species, the glands were capable of maximum flow rates similar to kangaroos. Both animals had high salivary protein with *Aepyprymnus* but not *Potorous* having high saliva and plasma amylase activity. *Aepyprymnus* had higher plasma and saliva urea, and S/P urea ratio than *Potorous*. At low flow rates, *Aepyprymnus* saliva had lower [Na], [Mg], [Cl] and osmolality and higher [Ca], [K], and [PO₄] than *Potorous* saliva whereas, at high flow rates, only [Na⁺] was lower and [Ca] higher. [H⁺] and [HCO₃] did not differ. Relative to the parotid saliva of the red kangaroo (a fore-gut fermenter), the parotid saliva of these Potoroinae had substantially lower [HCO₃] and lower rates of secretion of buffer anions on a bodyweight^{0.75} basis particularly for flow rates less than 50 % of the flow maximum.

Effect of corticosterone on avian resting metabolic rates.

William A. Buttemer, Lee B. Astheimer, and John C. Wingfield

Department of Zoology, University of Washington, Seattle, Washington, U.S.A.

(Present address of WAB: Dept. of Physiology, University of Tasmania, Hobart;
present address of LBA: Dept. of Anatomy, University of Tasmania, Hobart)

We measured resting nocturnal metabolic rates of Gambel's white-crowned sparrows (*Zonotrichia leucophrys gambelii*) and pine siskins (*Carduelis tristis*) before and after administration of corticosterone (B) at physiological levels. We found no effect of B on basal metabolic rate of either species but all birds treated with B showed significantly less variation in nocturnal metabolism over the 3-h measurement period than controls. These results, coupled with our observation of caged birds, suggest that corticosterone has no direct effect on avian basal metabolic rate but does reduce the responsiveness of birds to external stimuli and thus promotes nocturnal restfulness.

BLOOD OXYGEN CARRIAGE AND CHANGE IN HEMOGLOBIN DURING EARLY DEVELOPMENT OF THE TAMMAR WALLABY (*Macropus eugenii*)

Susan J. Calvert,¹ Robert A.B. Holland¹ and Lyn A. Hinds². ¹School of Physiol. & Pharmacol., University of NSW, Sydney NSW. ²C.S.I.R.O. Division of Wildlife & Ecology, Gungahlin, ACT.

It has been reported in nearly every viviparous species that the embryo or fetus has an oxygen equilibrium curve (OEC) to the left of the maternal curve, this assisting O₂ uptake. In contrast, studies on the Tamar Wallaby have shown the OEC just before and just after birth to be shifted to the right of the mother's curve (Baudinette et al., 1988; Holland et al., 1988; Tibben et al. 1991).

In the present study serial measurements of blood oxygen transport and Hb types have been made on the developing Tamar Wallaby. Twenty-one embryos/pouch young were examined at ages from 20 days (when the circulation has just formed) until 2 days after birth. Blood was obtained from the embryos after the adult was killed by cervical dislocation and the embryo dissected out.

OECs on the whole blood were determined using a modified HEM-O-SCAN. Measurements were made at various CO₂ tensions with standard conditions approximating physiological, being 36°C and PCO₂ = 40 Torr. The OECs of the early embryos had high P₅₀ values (mean = 44.6 Torr) and thus a right-shifted curve in comparison with the adult (P₅₀ = 25 Torr). There was no systematic change in P₅₀ between the 20 day stage and the 28 day stage (2 days after birth). The OECs of the prenatales and pouch young rose steeply above about 50% saturation. The Hill coefficient (n_H) in the upper part was greater than 4 (as high as 6.5) for all embryos and pouch young studied, suggesting aggregation of adjacent Hb tetramers. The Bohr effect (measured as $\Delta \log P_{50} / \Delta PCO_2$) was lower in the embryos and newborn, about 1/2 of the adult value.

Isoelectric focusing (IEF) showed the proportion of the 4 embryonic Hbs to change during early development. In the very early embryos (20 and 21 days) only 3 Hbs were present with the fourth appearing on day 22.

The right shift of the embryonic OEC in relation to the mother works against O₂ transfer to the embryo. However once O₂ is loaded, a right shifted and steep OEC is advantageous as it unloads O₂ to the tissues at higher PO₂ values.

Comparative Energetics of Four Species of Varanid Lizards

Keith Christian

Faculty of Science, Northern Territory University
P.O. Box 40146 Casuarina, NT 0811

The resting metabolic rates of *Varanus panoptes*, *V. mertensi*, *V. gouldii* and *V. rosenbergi* were determined by respiratory gas analysis, as were the maximal rates of oxygen consumption ($VO_{2\max}$) of the goannas running on a treadmill. The aerobic capacities of the four species are compared to each other and to comparable measurements from iguanid and scincid lizards in order to address the question: "How different are the energetics of varanid lizards?". This question is further explored by reference to field measurements of activity and metabolic rates from free-ranging iguanid and varanid lizards. Measurements of activity in the field suggest that some species of goannas have aerobic capacities that are rarely, if ever, exploited in nature. This paradox will be discussed in relation to the plasticity of the aerobic capacities of lizards in both proximate and evolutionary time-scales.

INHIBITION OF CARDIAC VAGAL ACTION BY GALANIN BUT NOT NEUROPEPTIDE Y IN THE BRUSH-TAILED POSSUM, *TRICHOSURUS VULPECULA*

G.P. Courtice, E.K. Potter, and D.I. McCloskey, School of Physiology and Pharmacology, University of New South Wales, P.O. Box 1, Kensington, Sydney NSW 2033, Australia.

Short periods of stimulation of the cardiac sympathetic nerves to the heart of anaesthetised dogs result in prolonged inhibition of the ability of the vagus nerves to slow the heart. This effect has been attributed to the release of neuropeptide Y (NPY) from sympathetic nerve endings. In 1986, an absence of NPY was reported in thoracic sympathetic ganglia in a marsupial, the brush-tailed possum, *Trichosurus vulpecula*. The question thus arose as to whether stimulation of cardiac sympathetic nerves which, in the possum lacked NPY, resulted in vagal inhibition as in the dog. The present study investigated the effects of stimulation of cardiac sympathetic nerves and administration of exogenous NPY and another neuropeptide, galanin (GAL), on cardiac vagal action in the anaesthetised possum.

Stimulation of the right cardiac sympathetic nerve for 2 min at 16 Hz in the presence of α and β -adrenoceptor blockade evoked attenuation of cardiac vagal action in eight possums. Intravenous injection of GAL (2-3.5 nmol/kg) evoked similar inhibition of cardiac vagal action, but NPY (6.5-10 nmol/kg) caused no inhibition of cardiac vagal action. The GAL injections caused a powerful pressor response: 62.9 ± 6.2 mmHg increase in systolic blood pressure. NPY caused a smaller pressor response: 34.4 ± 2.2 mmHg increase in systolic blood pressure.

In the possum, GAL but not NPY can mimic the effects of cardiac sympathetic nerve stimulation on vagal action. The result is consistent with sympathetic nerve released GAL being the agent responsible for prolonged vagal attenuation. Galanin also causes large pressor effects. This is the first mammal in which an increase in blood pressure has been found in response to GAL.

Thermoregulation and Metabolism in Gould's Long-eared bat, *Nyctophilus gouldi*.

Alison Curtin, Mike Thompson and Steve Morris.
School of Biological Sciences, University of Sydney, Sydney, NSW 2006

Nyctophilus gouldi is a tree dwelling insectivorous bat abundant in forested areas of south eastern and south western Australia. Like many small insectivorous mammals *N. gouldi* is heterothermic and adopts torpor during periods of environmental stress. Using standard flow-through respirometry measurements of oxygen uptake (VO_2) and carbon dioxide excretion (VCO_2) were made of postabsorptive bats during their resting phase at temperatures between 1°C and 35°C. Water loss, rectal body temperature and thermal conductance were also determined.

N. gouldi adopted torpor at temperatures below 30°C. From 30°C to 15°C VO_2 was reduced by 84% and VCO_2 by 87%. Similarly thermal conductance and body temperature were observed to decrease with ambient temperature down to 10-15°C. At temperatures below 10°C body temperature was regulated at/or above 12.5°C and as a result VO_2 , VCO_2 and thermal conductance increased. Water loss decreased with ambient temperature.

The use of small metabolic chambers (64.5 ml) and lengths of tubing reduced the dead space in the respirometry system allowing patterns of breathing to be observed. At temperatures between 10°C and 25°C periods of apnoea were observed to punctuate short bursts of breathing. Apnoea was greatest at 10°C (maximum observed 30 min) and decreased as temperature increased, however the volume of oxygen taken up during breathing bursts did not vary with temperature. At temperatures below 10°C where metabolic compensation was utilized to maintain body temperature at 12.5°C apnoea was not apparent. Similarly at 30°C and 35°C apnoea was not observed. Apnoea is considered to be a consequence of reduced metabolic rate such that the bats no longer need to breathe continuously to meet metabolic demands.

INFLUENCE OF BODY SIZE ON THE RESPIRATORY RESPONSES TO INCREASING METABOLISM IN DASYURID MARSUPIALS

T. J. Dawson, M. A. Chappell and Jillian F. Hallam.

School of Biological Science, University of N.S.W. KENSINGTON. N.S.W.

Despite having a basal metabolism that is 30% lower than that of placentals, marsupials have an aerobic capacity that is at least equal to that of the placentals, i.e. marsupials have a relatively high metabolic scope. Further, the pattern of ventilation in marsupials also appears different. Marsupials have resting, basal respiration rates that are half of those of placentals but tidal volumes are 1.5 times the placental values. How do the dasyurids adjust this respiratory pattern to achieve their high aerobic capacity, and does body size have an influence on this response?

The dasyurid examined were *Planigale tenuirostris*, *Sminthopsis crassicaudata*, *Antechinus swansonii* and *Dasyuroides byrnei*. These species ranged in mass from 5g to 140g. In all species metabolism was increased up to summit metabolism (maximum sustained thermogenic metabolism), which was 10-12 time basal levels. In the larger species a helium-oxygen environment was used to attain summit metabolism. The pattern of response was similar in all species. Ventilation was increased by both increases in tidal volume and respiration rate, with the increases in tidal volume tending to precede marked changes in rates. While increases in the level of oxygen extraction were not noted in the responses, it was obvious that the smaller species generally had much lower levels of oxygen extraction.

ACIDOSIS IN FOLIVOROUS MARSUPIALS

William J. Foley

Zoology, James Cook University

Koalas, greater gliders and common ringtail possums develop a metabolic acidosis after eating Eucalyptus leaves that contain large concentrations of terpenes and phenolics. Ringtails fed E. radiata foliage excreted acid urine (pH 5.7) that was rich in ammonium but contained little urea. In contrast animals fed E. ovata foliage excreted an alkaline urine containing predominately urea. This pattern may result from the accumulation of organic acids resulting from the detoxification of terpenes and phenolics. Although animals eating both diets recycled a similar proportion of the synthesised urea, the quantitative importance of this was much greater in the non-acidotic diet. It was predicted that there would be a daily cycle in blood acid base status related to time after feeding and results from a pilot study on one koala will be presented.

**METABOLISM AND VENTILATION DURING ACUTE HYPOXIA IN ADULT MAMMALS:
A COMPARATIVE ANALYSIS IN SMALL SPECIES.**

P.Frappell¹, C.Lanthier², R.V.Baudinette³, and J.P.Mortola¹

¹Department of Physiology, McGill University, 3655 Drummond Street, Montreal, Quebec, H3G 1Y6, Canada; ²Société Zoologique de Granby, Granby, Québec, Canada; ³School of Biological Sciences, The Flinders University of South Australia, GPO Box 2100, Adelaide, S.A.5001, Australia.

Oxygen consumption (\dot{V}_{O_2}), CO₂ production (\dot{V}_{CO_2}) and ventilation (\dot{V}_E) have been measured during normoxia and hypoxia (10-20 min in 10% O₂) in specimens of 27 species from 6 mammalian orders, ranging in body mass (M) from a few g to several kg. In normoxia, both metabolism and \dot{V}_E scaled close to M^{3/4}, \dot{V}_E/\dot{V}_{O_2} and \dot{V}_E/\dot{V}_{CO_2} therefore being independent of M. In hypoxia, \dot{V}_E /metabolism increased in all species (in average more than 100%), mostly because of a drop in \dot{V}_{O_2} . In average, \dot{V}_E was 23% above the normoxic value, but in some species decreased below normoxia. \dot{V}_{O_2} dropped in all but one species, in average 35%. Body temperature decreased by variable amounts, usually more in the smallest species. The decrease in metabolism during hypoxia was positively correlated with the resting metabolic rate of the species, in a manner very similar to what can be calculated from data of previously studied newborn mammals. Hence, hypoxia may decrease metabolic rate by decreasing thermogenesis, with larger effects in smaller animals, whether newborns or adults, because of their higher thermogenic requirements. We conclude that 1) hypoxic hypometabolism is a general characteristic of the mammalian response to hypoxia, and cannot be neglected in the interpretation of ventilatory and cardiovascular responses, 2) its magnitude is inversely related to the resting \dot{V}_{O_2} of the species, and therefore could be less prominent or possibly absent in adults of larger species.

TRANSFER OF THYROXINE IN THE MILK OF TWO MARSUPIALS, THE NORTHERN BROWN BANDICOOT, ISOODON MACROURUS AND THE BRUSHTAIL POSSUM, TRICHOSURUS VULPECULA.

Robert T. Gemmell and Conrad Sernia.
Departments of Anatomy and Physiology and Pharmacology,
University of Queensland.

The bandicoot and the possum give birth to young with a body weight of 250 mgm. The young of the bandicoot are weaned at day 59 whereas the young of the brushtail possum are weaned at day 200 post partum. At day 50 post partum, the bandicoot and possum young weigh approximately 100 grm and 20 grm, respectively. The aim of this study was to determine whether the transfer of thyroxine via milk from the mother to the developing young was responsible for these disparate growth rates. Radioactive thyroxine was injected intramuscularly into the lactating female and 24 hours later a blood sample was obtained from the mother and the pouch young removed. The amount of radioactivity and subsequently the concentration of thyroxine in the blood and within the young were determined. The data obtained concurs with the suggestion that milk is a possible source of thyroid hormones in early pouch life (Janssens et al. 1990). However, the hypothesis that greater quantities of thyroxine are transferred in the milk of bandicoots than that of brushtail possums is not supported.

ERYTHROCYTE METABOLISM IN DIVING (*TURSIOPS TRUNCATUS*) AND FLYING MAMMALS (*MINIOPTERUS SCHREIBERSII*, *PTEROPUS SCAPULATUS*)

I.R. Godwin, N.S. Agar and G.A. Chaffey

**Department of Physiology, University of New England, Armidale, NSW
2351, Australia**

Both diving and flying require physiological adaptations to allow for greatly changed oxygen availability and/or needs. Very little information is available on the erythrocytes (the prime oxygen carrier) of species exhibiting these traits. Erythrocyte enzyme activities, substrate utilization and basic haematology were determined on bent wing bats (*Miniopterus schreibersii*), fruit bats (*Pteropus scapulatus*) and bottlenosed dolphins (*Tursiops truncatus*). The haematocrit and haemoglobin levels were similar for the three species, but the mean corpuscular volume was larger for the dolphin and smaller for the bats. The red cell counts however were the reverse. The levels of red cell 2,3-diphosphoglycerate and adenosine triphosphate were relatively high in all three species. The most notable differences in the enzyme activities were much higher levels of all glycolytic enzymes in bent wing bats than in the two other species and low levels of glucose phosphate isomerase in the dolphin. The dolphin red cells had much lower glycolytic rates as measured by lactate production using different substrates. The bent wing bats had extremely high rates of lactate production from both glucose and mannose.

THERMAL PHYSIOLOGY OF THE SCORPION URODACUS MANICATUS

Chris Holden

Department of Zoology, University of New England
Armidale, N.S.W. 2351

Standard metabolic rates (SMR) and thermal preferences of the scorpion Urodacus manicatus from Dubbo and Black Mountain (N.S.W.) were compared to assess differences in acclimatisation in semi-xeric and mesic seasonal climates. Rate-temperature curves were determined between 20 and 40°C and thermal preferences were determined in a temperature gradient for scorpions from the field at different seasons of the year. SMR in winter, spring and autumn and preferred temperature in winter were greater for scorpions from Dubbo than those from Black Mountain. Acclimatisation was not apparent in scorpions from Dubbo in autumn, winter and spring. Black Mountain scorpions showed an annual peak of SMR in summer, the lowest in autumn and spring and selected the highest temperatures in spring. Black Mountain males showed higher SMR than females in autumn and spring. Males from both sites selected lower temperatures than females in spring. These patterns of acclimatisation reflect seasonal activity and environmental temperatures at the two sites.

OXYGEN CARRIAGE IN BLOOD OF NEONATES AND ADULTS OF THE BRUSHTAIL POSSUM (*Triochosurus vulpecula*). Robert A.B. Holland,* Susan J. Calvert* and Robert T. Gemmell†. *School of Physiology and Pharmacology, University of New South Wales, NSW, 2033; and †Dept. of Anatomy, University of Queensland, QLD, 4067.

It is well known that in viviparous vertebrates the blood oxygen equilibrium curve (OEC) of the fetus or embryo is normally to the left of that of the mother, this aiding the transfer of oxygen to the developing animal. However prenatal and neonatal Tammar Wallabies have OECs to the right of the maternal curves. They also have a decreased Bohr shift; a steeply climbing OEC above about 50% saturation; and four Hb types, each different from the major and minor components of adult haemoglobin.

We wished to find whether these features were peculiar to the Tammar Wallabies or were found in other marsupials. For further experiments the Brushtail Possum of the family Phalangeridae was chosen because of its relative availability, being bred in captivity at the University of Queensland. Like all marsupials it is born at a very immature stage. Unlike the Tammar, the possum does not carry a dormant blastocyst but after removal of pouch young, the females come into oestrus, may be fertilized about 8 days later, and give birth to a single young after 17 days gestation. Pouch young were removed from 11 possums. Blood was obtained from 5 mothers (heart puncture) and from 6 neonates (after decapitation; about 4 μ l from each).

OECs were determined on a modified HEM-O-SCAN using a thin film of blood, at 36°C and CO₂ pressures of 21, 42, and 72 Torr. At 42 Torr PCO₂ mean P₅₀ of the neonates was 43.3 Torr (SE = 0.86) and 35.6 Torr (SE = 0.83) for the 5 adults. The effect of CO₂ on P₅₀ was low in the neonates. The neonates had a high climbing OEC above 50% saturation and the Hill plot in this region showed n_H values of greater than 4, this suggesting aggregation of Hb tetramers. Adult OECs were of normal shape with n_H always below 4. The neonatal blood had 4 Hb types, all different from the major and minor Hb components of the adult. Non-nucleated red cells had begun to appear in the 2 day old and were plentiful in the 4 day old.

These results are similar to those found in Tammar Wallaby neonates. The findings are likely to be general in marsupials and related to their immaturity at birth.

Membrane fatty acids and adaptations to the environment.

A.J.Hulbert¹, Patrice Couture¹, Kerry Withers¹ and P.A. Janssens².

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The fatty acid composition of cellular membranes appears to be a regulated phenomenon and may be one of the earliest homeostatic responses to fluctuations in the environment. Fatty acids can be classified into several categories including the dietary essential omega 6 and omega 3 polyunsaturates. Membrane fatty acids are important both as structural components of the membrane and as precursors of intracellular messengers. The "fluidity" (or "viscosity") of a membrane is very influenced by its fatty acid composition which appears to be controlled by various desaturase enzyme complexes in the membrane. The concept of "homeoviscosity" can explain many of the variations in membrane fatty acid composition. Membrane fatty acid composition will be discussed in relation to (i) the dietary requirements of different groups of mammals, (ii) the difference between tissues from endotherms and ectotherms, (iii) the difference between tissues from small and large mammals, (iv) changes during mammalian development, (v) effects of hormones on membrane fatty acid composition and the interaction between diet and hormonal effects, (vi) changes in the membrane fatty acids of intertidal organisms and, (vii) changes in membrane fatty acids during the cell cycle.

DIGESTIVE FUNCTION IN SOME NORTH AMERICAN RODENTS

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ABSTRACT

Townsend voles (Microtus townsendii) and three species of sciurid rodents - yellow-pine chipmunks (Eutamias amoenus), Columbian ground-squirrels (Spermophilus columbianus) and hoary marmots (Marmota caligata), were fed diets of three different fiber contents (7, 22 and 28% acid-detergent fiber). Rate of passage of fluid digesta was measured with the marker Co-EDTA, and that of large particles with Cr-mordanted cell walls.

In voles the mean retention time (MRT) of fluid (14.8 ± 1.9 h) was greater ($P=0.02$) than that of large particles (13.1 ± 2.4 h), indicating selective retention of fluid digesta, probably in the cecum. In contrast, in the three sciurids MRTs of fluid were not different from, or were less than, those of large particles. MRTs increased with increasing body size. Voles digested more dry matter than chipmunks of similar body size on all three diets. Chipmunks lost body mass on the high-fiber diet. Marmots digested more dry matter than voles on the low-fiber diet, but not on the high-fiber diet.

Results support the prediction that voles can utilize more fibrous feeds than chipmunks because of a more complex proximal colon and larger cecum, but that within the Sciuridae large body size (and hence a large absolute gut capacity relative to metabolic rate) offsets the disadvantage of a relatively simple hindgut.

Adrenergic receptors in non-mammalian vertebrates.

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Catecholamines influence hepatic metabolism, causing glycogen breakdown and glucose release. This action occurs via α -adrenergic receptors in some mammals but via β -adrenergic receptors in those teleosts, lungfishes, amphibians and reptiles which have been studied. There is, however, an involvement of Ca^{2+} in regulation of glucose release by catecholamines in the skink, *Trachydosaurus rugosa*, and we have been trying to determine whether α -adrenergic receptors are involved in regulation of hepatic glycogenolysis in this species.

Both ligand-binding studies and studies involving the use of adrenergic antagonists are consistent with there being only one adrenergic receptor in *T. rugosa*. There is substantial binding of β -adrenergic ligands to hepatic membrane preparations but none for binding of the α -adrenergic ligands prazosin or yohimbine. However, the α -adrenergic antagonist phentolamine blocks the glycogenolytic action of both adrenaline and phenylephrine (putative α -agonist) with similar dose-response characteristics. We think it likely that there is only one adrenergic receptor in the liver of *T. rugosa*. This receptor appears to have characteristics intermediate between α - and β -adrenergic receptors of mammals.

**Aquatic oxygen uptake of a freshwater
turtle, *Elseya* sp.**

Peter King, U.N.E., Armidale.

Pulmonary and non-pulmonary oxygen uptake were measured in one species of freshwater turtle, *Elseya* sp., from the Bellinger River, N.S.W., at 3 temperatures 10°C, 20°C and 30°C. Aquatic oxygen uptake was not merely passive diffusion over the dermis. Three body areas considered important for gas exchange were isolated and oxygen uptake measured. Relative importance of aquatic respiratory surfaces were measured at; buccopharyngeal cavity 49.2% (SE 2.8%), cloaca, including cloacal bursae 32.6% (SE 1.8%) and dermis 18.2% (SE 2.5%) in free-diving turtles. Aquatic oxygen uptake in forcibly submerged, but free-swimming turtles was approximately twice that of free-swimming turtles that had access to air.

LACTATION AND ENERGETICS IN THE KOALA

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Energetic investment in reproduction is often used to explain ecological phenomena but is rarely quantified. Lactational energy expenditure and the concomitant habitat and nutrient requirements are important aspects of reproductive investment in mammals.

Milk production was estimated by a double isotope method in females carrying furred young (6 of the 11 months of lactation). The individual curves consist of a steep rising phase, peak and slower decay. Juvenile Koalas begin to ingest significant quantities of foliage after the peak of lactation when the young are between 0.5 and 1.0 kg body weight and are fully weaned at 1.5- 3.0kg.

Lactating female Koalas showed a peak in water turnover around the time of peak lactation suggesting an elevated food intake at this time. However, field metabolic rates of lactating and non-lactating females were not significantly different at any time. I suggest that this extra energy intake in lactating females is diverted almost directly to milk production. It is also possible that females compensate for lactational energy costs in some other way, possibly by reducing activity and ranging behaviour.

Locomotion in small Macropodids

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Kensington N.S.W. 2033

Studies were performed on the metabolic costs of locomotion in two Potoroos (*Potorous tridactylus*) and three Bettongs (*Bettongia penicillata*), each of body weight approx. 1 kg. The Potoroos used quadrupedal locomotion at all speeds on the treadmill, and their oxygen consumptions were linearly related to speed ($R^2 = 0.93, 0.98$), and close to the levels predicted by Taylor, Heglund and Maloiy (1982) for quadrupeds. The Bettongs hopped at all speeds tested, and their oxygen consumptions were sigmoidally related to speed showing a flattened (but not completely independent of speed) relation across an intermediate range of speeds. Within this speed range, oxygen consumption changed less with speed than predicted for quadrupeds of this body weight, and was less than values predicted for quadrupeds towards the upper end of this range.

The energetically optimal speed of locomotion in these animals was also assessed. Analysis of a high-speed videotaped record of the gait of the Bettongs showed that, although speed is increased almost entirely by increasing stride length while stride period is maintained almost constant, the period of ground contact within each stride decreases with speed.

Taylor, C.R., Heglund, N.C. and Maloiy, G.M.O., 1982. Energetics and mechanics of terrestrial locomotion. *J. exp. Biol.* 97:1-21

**Maintenance energy and nitrogen requirements of the magpie
goose, *Anseranas semipalmata*.**

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In the early 1900's, magpie geese (*Anseranas semipalmata*) breeding colonies ranged from northern Australia to coastal Victoria and South Australia. Habitat destruction, poisoning and hunting has restricted their breeding range to the swamp lands and flood plains of northern Australia, and reduced them to vagrants in the south. A hunting season still exists in the north, and interest has been expressed in farming these birds. A study of magpie goose dietary requirements is being undertaken to facilitate the commercial rearing of these birds.

Wild magpie geese feed on bulbs, wild rice and herbage such as the flood plain grass, *Hymenacnae* sp., depending on their availability. In our experiment, magpie geese kept in metabolism cages were fed either husked rice (containing 8% water) or *Hymenacnae* sp. (containing 74% water). As part of a larger study we measured energy and nitrogen maintenance requirements. The energy content of the two diets were similar : rice 18.25kJ/gDM ; *Hymenacnae* 20.5kJ/gDM while nitrogen content differed remarkably : rice 0.012gN/gDM ; *Hymenacnae* 0.026gN/gDM. Magpie geese fed on rice have a maintenance energy requirement of 600kJ/kg/day and a maintenance nitrogen requirement of 0.27gN/kg/day. Birds fed *Hymenacnae* sp. were unable to maintain body weight.

**Respiratory, ion and acid-base regulation in the amphibious crab,
Leptograpsus variegatus.**

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School of Biological Sciences, University of Sydney, Sydney, NSW 2006

Leptograpsus variegatus is locally common crab and was collected from a number of rocky headlands around Sydney beaches. During collection it was observed that the animals seem to prefer breathing air, rather than water. At night the animals were observed well above the intertidal zone and only retreated into the water when coerced. Respiratory and ionic processes were examined in *Leptograpsus* during amphibious behaviour in the laboratory.

The possibility of neurohormonal control of Na^+/K^+ ATPase catalysing Na^+/K^+ exchange with seawater by the gills was investigated in a series of *in vivo* and *in vitro* experiments. Incubating gill sections and homogenates in dopamine (crustacean monoamine hormone) and cAMP (putative intracellular 2nd messenger) indicated that dopamine *via* cAMP was important in stimulating gill ion exchange. The most conclusive data came from *in vivo* work which showed that dopamine does have a significant effect on Na^+/K^+ -ATPase activity. This potentially allows the crab to stimulate ion-regulatory systems in water but to "turn them down" in air.

Simulated 12 h water breathing, after air-breathing, followed by return to air showed *Leptograpsus* to be an accomplished amphibian. Although CO_2 levels in the haemolymph declined while breathing water, characteristic of water breathers, there was only a transitory acid-base perturbation upon entry into water. Haemolymph oxygen content and partial pressure both declined while breathing water but the arterial-venous difference remained unchanged and the venous saturation never fell below 50%. In line with this maintained aerobic status there was no increase in circulating lactate as would be expected if moving between air and water compromised aerobic metabolism. *Leptograpsus* is an amphibious species, providing an excellent study species for elucidating some of the adaptations involved in the ongoing radiation of the Crustacea into the terrestrial environment.

Blood Viscosity in Penguins

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Penguins have large nucleated red cells, and Block and Murrish (1974) have suggested that the large size is an adaptation to the cold antarctic aquatic environment. Block and Murrish argue that a large red cell size results in a high blood viscosity at low temperatures, which will result in a reduced peripheral blood flow, and in turn in reduced heat loss. To test this convoluted physiological reasoning we examined blood viscosity of little penguins (*Eudyptula minor*) which have red cells of a similar size to antarctic penguins, but whose range is restricted to water temperatures above 10°C. Despite the large red cells, at low temperatures little penguin blood had a lower viscosity than chicken blood. Subsequent measurements on blood from antarctic Adélie penguins (*Pygoscelis adeliae*) yielded surprising results.

Block, GA and Murrish DE (1974). Viscous properties of bird blood at low temperatures. *Antarctic Journal of the U.S.* 9: 98-99.

CARDIAC RESPONSES ATTRIBUTED TO SOMATOSTATIN ARE DIMINISHED BY REPETITIVE STIMULATION OF CARDIAC VAGAL NERVES IN THE TOAD

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Short periods of high frequency stimulation of the vagal nerve fibres to the heart in the toad *Bufo marinus*, result in potentiation of cardiac cholinergic vagal action on the heart. That is, the vagus slows the heart more effectively after such a stimulus. This effect has been attributed to the neuropeptide, somatostatin (SOM). Atropine resistant slowing of the heart after vagal stimulation has also been attributed to SOM. These two responses to vagal stimulation were tested in 16 toads both before and after a 1 hour period of stimulation of the vagus nerves (10Hz, 1 ms, 5V for 30 s every 60 s). Both potentiation of cardiac vagal action and direct cardiac slowing in response to vagal stimulation were significantly reduced after the 1 hour stimulation period. The responses to administration of exogenous SOM were unaffected.

These results suggest that the two cardiac responses are indeed due to release of a neuropeptide, probably SOM, which is depleted from nerve endings during prolonged (1 hr) stimulation.

RESPONSES TO DEHYDRATION IN GREEN TREE FROGS (*Littoria caerulea*) AND
CANE TOADS (*Bufo marinus*).

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Plasma and (where possible) urine were collected from fully hydrated frogs and toads and from animals which had been subjected to water deprivation. Frogs were dehydrated until they had lost an average of 18% of initial body weight. Toads were dehydrated under two different regimes: at a lower humidity over a period of 3 days (average loss of 17% of initial body weight) and at higher humidity over a period of 8 days (average loss of 30% initial body weight). In dehydrated frogs, haematocrit and the plasma concentrations of chloride and urea were significantly higher than in hydrated animals. Plasma osmolality and uric acid concentrations tended to be higher in dehydrated frogs although these differences were not statistically significant. The uric acid concentration of the urine of hydrated frogs was $12.9 \pm 5.5 \text{ umol.l}^{-1}$. However, no urine was obtained from dehydrated frogs. Plasma osmolality and the plasma concentrations of chloride and uric acid were greatest in the toads which were dehydrated over 8 days (long term - LT). Similar trends were apparent for urine. However, the concentrations of urea in plasma and urine were highest in the toads which were dehydrated over 3 days (short term - ST). Both species appear to produce some uric acid and the levels in plasma increase with dehydration.

PROSTAGLANDIN F2 α AND THE CONTROL OF REPRODUCTION IN THE
TASMANIAN BETTONG, *Bettongia gaimardi*.

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On the same night that her furred young finally leaves the pouch, a bettong gives birth to a new young (born as a result of the activation of a diapausing blastocyst) and mates post-partum. Our hypothesis has been that the reproductive hormones involved in parturition are also involved in pouch vacation.

Experiments with bromocriptine have failed to produce premature pouch vacation although in other macropodids this chemical results in immediate resumption of development of the blastocyst in diapause' followed by birth. Prostaglandin F2 α is implicated in the birth process in many mammals. When injected' (0.05-0.1 mg kg⁻¹)' PGF2 α results in birth behaviour in frequently handled bettongs (and in 10 other marsupial species). It also causes temperature rises (1.5°C), 'centrally mediated' contraction of the pouch and subsequent pouch vacation by young if they are 12 weeks or older; they remain out for some hours before returning to the pouch.

Colonic absorption and nasal gland development in relation to NaCl intake in the ostrich (*Struthio camelus*)

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The ostrich is unique among the ratite birds in having a colon more than 10 m long. It functions as a fermentation chamber, as in many mammalian herbivores. Concentrations of short chain fatty acids reach more than 200 mM. This investigation examines the possible regulation of the electrolyte and SCFA absorption in the colon in relation to the NaCl content of the diet. This was studied in semi-domesticated animals prior to commercial slaughtering. The birds were subjected to a high, a medium, and a low NaCl diet. For 3 days before slaughter they were offered drinking water containing a water marker, polyethylene glycol 4000. This allowed calculation of relative absorption rates along the length of the gut, as samples of the contents were taken immediately after slaughter at one meters distance. Plasma and urine samples were also secured, and the heads were dissected, and the weights of the nasal glands measured. The results indicate a pronounced decrease of colonic NaCl and SCFA absorption induced by NaCl-loading, thus possibly compromising energy uptake. The nasal glands were not significantly stimulated by NaCl.

Osmoregulation and Ammonia Excretion in the crab *Geograpsus grayi*

Glenn Varley and Peter Greenaway

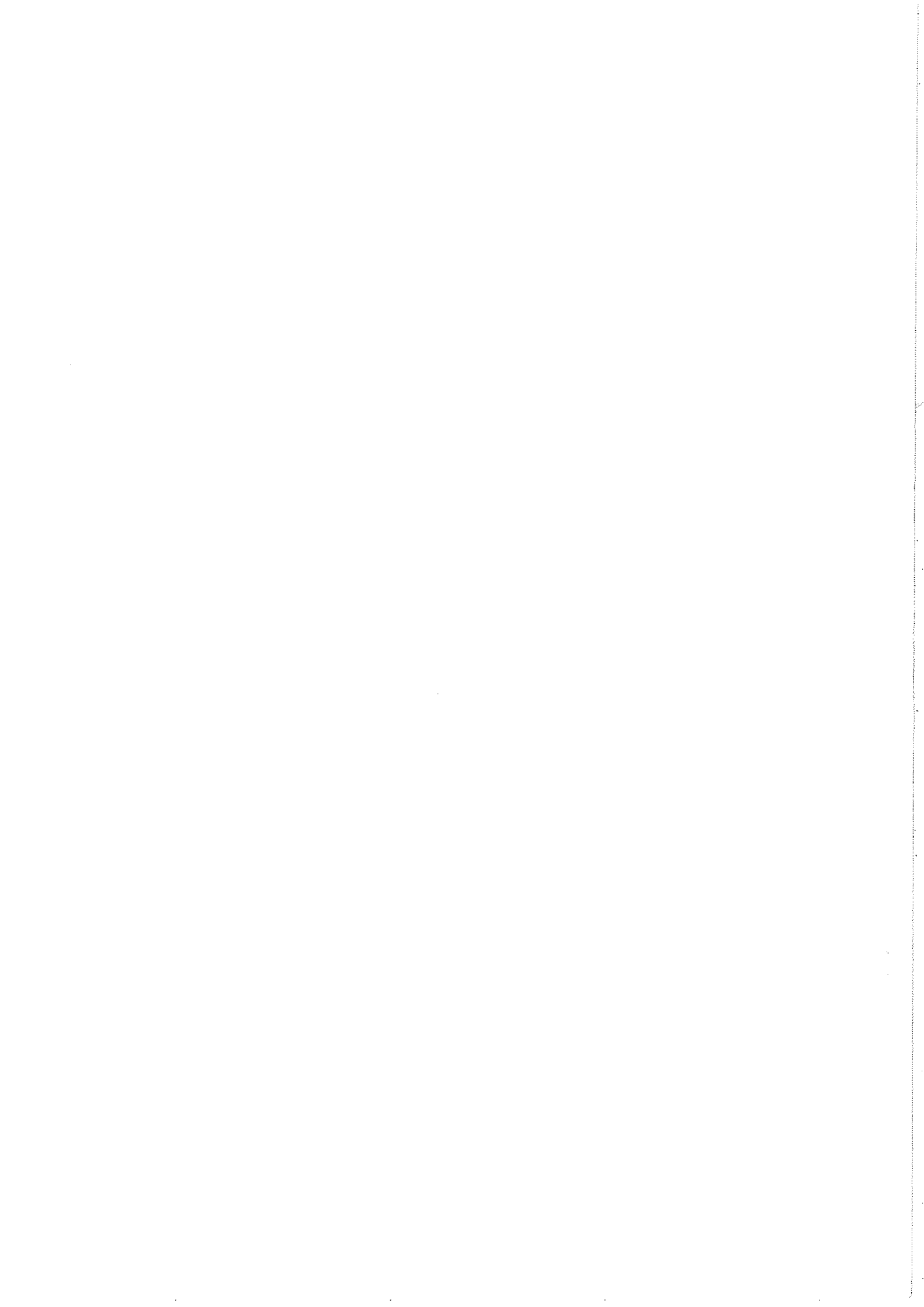
School of Biological Science, University of N.S.W.

The effect of ion exchange inhibitors on the apical membrane of the gill epithelium in *Geograpsus grayi* was examined. The presence of an amiloride sensitive $\text{Na}^+/\text{NH}_4^+$ exchanger and a SITS sensitive $\text{Cl}^-/\text{HCO}_3^-$ exchanger was confirmed. Inhibition of either of these ion exchange mechanisms caused an inhibition of ammonia excretion into artificial urine infused into the branchial chambers.

Animals were able to maintain osmotic balance given either distilled water or 100% sea water to drink, adjusting the osmotic concentration of the final excretory product to match the concentration of fluid intake under conditions of minimal desiccation.

There was no significant difference ($p < .05$) between mean rates of gaseous ammonia production between fed ($80.5 \pm 17 \text{ SEM } \mu\text{moles.kg}^{-1}.\text{h}^{-1}$, $n=7$) and starved crabs ($79.4 \pm 21 \text{ SEM } \mu\text{moles.kg}^{-1}.\text{h}^{-1}$, $n=8$) or between crabs drinking sea water ($88.3 \pm 19 \text{ SEM } \mu\text{moles.kg}^{-1}.\text{h}^{-1}$, $n=6$) and distilled water ($74.3 \pm 19 \text{ SEM } \mu\text{moles.kg}^{-1}.\text{h}^{-1}$, $n=9$).

This data supports the data from previous studies that gas excretion is achieved by concentrating NH_4^+ in the branchial fluid using ion exchange mechanisms in the gill epithelium but also illustrates that this species has a high capacity for osmoregulation and is capable of maintaining a salt balance regime consistent with the role of Na^+ and Cl^- ions in nitrogen excretion.



The Number and Activity of Sodium Pumps in Endotherms and Ectotherms: Do they support the "Leaky" Membranes Hypothesis?

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The "leaky" membranes hypothesis proposes that during the evolution of endothermy an increase in the passive permeability or "leakiness" of membranes to ions has occurred that requires additional energy to service. The benefit is increased heat production. So far work has concentrated on Na^+ , K^+ and the sodium pump. Support for this hypothesis includes; indirect measurements of the energy used on sodium pumping and direct measurements of the "leak" of Na^+ and K^+ being several fold greater in the tissues of endotherms.

The hypothesis requires a net increase in sodium pump activity in tissues from endotherms. This may occur by more sodium pumps and/or greater activity per se. These possibilities were investigated in kidney, liver, heart and skeletal muscle in salamander, toad, crocodile and rat. Techniques included ^3H -ouabain binding to determine the numbers of sodium pumps and a NaKATPase assay to determine activity. Although not all possible combinations of organs, tissues, species and techniques could be measured a general picture emerged that suggests that sodium pump number is similar in endotherms and ectotherms. However, the NaKATPase assays produced sodium pump activities that were consistently and substantially greater in the organs and tissues of the endotherm measured. Therefore it would appear that the activity of sodium pumps per se (ie the molecular activity) is several fold greater in tissues of endotherms compared to those of ectotherms and that in the evolution of endothermy the number of sodium pumps has not changed but the molecular activity has increased.



