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Effects of Body Mass and Temperature on Standard Metabolic Rates for Two Australian Varanid Lizards (Varanus gouldii and V. panoptes)

Graham G. Thompson and Philip C. Withers

Standard metabolic rates (SMR) for two varanid lizards (Varanus gouldii and V. panoptes) were measured from 2400 and 0800 h, after the lizards had rested for at least 8 h. The relationship between SMR (VO₂; ml/h) and body mass for varanids at 20 C is 0.04 g⁻⁰.⁰²; at 30 C, 0.030 g⁻¹.⁰²; at 35 C, 0.089 g⁻¹.⁰⁵ and at 40 C, 0.144 g⁻¹.⁰⁶. The relationship between SMR (VCO₂; ml/h) and body mass at 20 C is 0.017 g⁻¹.⁰⁴; at 30 C, 0.028 g⁻¹.⁰²; at 35 C, 0.045 g⁻¹.⁰⁹ and at 40 C, 0.107 g⁻¹.⁰⁴. There were no significant differences in the mass exponent between species at any temperature (20–40 C), with the pooled slope for V. gouldii of 1.12, for V. panoptes 1.10, and an overall pooled slope of 1.11. No plateau in VO₂ was found between the Tₘ of 30–40 C as previously reported for V. gouldii and V. rosenbergii.

LARGER lizards consume more oxygen than smaller lizards but less oxygen per gram body mass (see reviews of Bennett and Dawson 1976, and Bennett 1982). The allometric relationship between standard metabolic rate (SMR, ml O₂/h) and body mass (M; g) is SMR = aMᵇ, where a is the mass coefficient (SMR of a 1 g lizard) and b is the mass exponent (slope of a double logarithmic plot of SMR and M).

The relationship for mass-specific metabolic rate (e.g., ml O₂ g⁻¹ h⁻¹) is SMR/M = aMᵇ⁻¹. Andrews and Pough (1985) report the mean mass exponent (b) of the multiple regression equation for 107 species of squamates as 0.80 (±SE b = 0.012). They also report no difference in the mass exponent (P < 0.05) between Varanidae (the family with the highest mean SMR) and Boidae (the family with the lowest SMR).
The mean intraspecific mass exponent for 17 species was 0.67.

Bennett (1972) reported that the SMR (VO₂) was independent of body temperature (Tₛ) from 30–40 C for V. gouldii and V. rosenbergi, whereas Earl (1982) reported a linear semilogarithmic relationship between VO₂ and Tₛ for V. bengalensis from 20–40 C.

The objectives of this study were to (1) compare the inter- and intraspecies relationship of SMR to body mass for two species of varanids (Varanus gouldii and V. panoptes) over a wide range in mass; (2) compare the interspecies allometry of SMR for Varanus with that of other lizards; and (3) examine the effect of Tₛ on SMR and determine whether SMR was “essentially independent of Tₛ between 30 and 40 C” as reported by Bennett (1972) for V. gouldii and V. rosenbergi.

**Materials and Methods**

Seven V. gouldii (20–555 g) and 12 V. panoptes rubidus (227–3480 g) were collected under license from various locations in Western Australia and maintained at the University of Western Australia either in outdoor pens under natural photoperiod or indoors in cages with incandescent lighting for 12 h/day. The varanids were fed raw meat, live mice, or freshly killed mice. Water was provided at all times. Animals were fasted for at least 48 h prior to the measurement of metabolic rates. The SMR (VO₂) and carbon dioxide production (VCO₂) were determined only once for each lizard at each temperature, although not all individuals were measured at all temperatures.

Oxygen consumption rate (VO₂; ml O₂/h) and carbon dioxide production rate (VCO₂; ml CO₂/h) were measured using a flow-through respirometer system. The lizards were placed in opaque plastic cylinders that restricted but did not prevent voluntary activity. These cylinders were placed in a controlled temperature chamber at 20 C, 30 C, 35 C, and 40 C. Compressed air (<4 mg water/l) was passed through the chamber at a flow rate (25–400 ml/min) that was adjusted according to the size of the lizard so that the excurrent O₂ content was about 20.1%. The temperature of the air in the chamber (Tᵥ, C) was constantly measured with a chromel-alumel thermocouple. Cloacal temperatures (Tᵥ, C) of the varanids were taken at the end of the measurement period to ensure that Tᵥ and Tₛ were essentially the same. Excurrent air was dried with a silica gel column before passing through one channel of a paramagnetic oxygen analyzer (Servomex 184A) and a CO₂ analyzer (Hereus-Leybold Binos). The differential output of the oxygen analyzer (ambient air-excurrent air) and the analog outputs of the CO₂ analyzer and thermocouple were connected via a multiplexer to a digital multimeter (Keithley 177). The BCD output of the multimeter was interfaced to a microcomputer (Commodore 128 and Schneiderl 641F22 V1A board) that monitored ambient temperature and excurrent O₂ and CO₂ content. The microcomputer calculated STPD VO₂ and VCO₂ every 60 sec for 16–20 h periods, commencing between 0800 and 1400 h. The lizards were at their lowest VO₂ level for the period from 2400–0800 h. The analog outputs of the O₂ and CO₂ analyzers were averaged for 25 consecutive values over about 40 sec to calculate a VO₂ and VCO₂ each 60 sec; the 60 sec values were stored on disk for subsequent analysis. The VO₂ and VCO₂ were calculated after Withers (1977). The minimum (i.e., standard) VO₂ and VCO₂ were calculated as the average for the longest continuous period of low VO₂ (normally 20–100 min). This ensured that the calculated value was SMR, and not affected by brief periods of activity, or transiently low VO₂ or VCO₂ values that were occasionally observed, presumably due to short apneic periods.

The difference in SMR between species and temperatures was tested by two-factor ANOVA (unequal sample sizes; Statview Software). The difference between the regression equations for the two species was tested by ANCOVA and Tukey Q test (Zar, 1984).

**Results**

Minimum metabolic rates.—Most lizards needed at least 8 h to reach minimal levels of VO₂ and VCO₂, and some required up to 16 h before minimal VO₂ and VCO₂ were attained. In many instances, there was a spontaneous increase in VO₂ and VCO₂ at about dawn, presumably reflecting a circadian rhythm in activity, hence metabolic rate. The mean minimal SMR values for each species at each Tᵥ investigated are summarized in Table 1.

There was no significant difference in SMR between the two species at any Tᵥ’s (two-factor ANOVA; P = 0.24 for species), but there was a highly significant temperature effect (P < 0.0001); there was no significant interaction ef-
fect \( (P = 0.298) \). There was a significant difference in \( \dot{V}CO_2 \) between the two species of varanids (two-factor ANOVA; \( P = 0.037 \)), a highly significant effect of temperature on \( \dot{V}CO_2 \) \( (P = 0.0001) \), and no significant species-temperature interaction \( (P = 0.65) \).

There was no significant difference in respiratory quotient (RQ) for the varanid species (two-factor ANOVA; \( P = 0.058 \)) or any difference at any of the temperatures \( (P = 0.378) \). There was a significant interaction effect for RQ with species and temperature \( (P = 0.028) \).

**Table 1. Mass-Specific Standard Metabolic Rate \( (\dot{V}O_2 \text{ and } \dot{V}CO_2; \text{ml g}^{-1} \text{h}^{-1}) \) at Various Ambient Temperatures for Two Species of Varanids. Values are mean, \( \pm SE \) with the sample size \( (n) \).**

<table>
<thead>
<tr>
<th>( T_s \text{ C} )</th>
<th>Mass (g)</th>
<th>( \dot{V}O_2 )</th>
<th>( \dot{V}CO_2 )</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>V. gouldii</td>
<td>19.7</td>
<td>76.9 ± 35.7</td>
<td>0.0582 ± 0.0061</td>
<td>0.0225 ± 0.004</td>
</tr>
<tr>
<td></td>
<td>30.7</td>
<td>169.0 ± 67.3</td>
<td>0.0678 ± 0.0156</td>
<td>0.0527 ± 0.010</td>
</tr>
<tr>
<td></td>
<td>35.5</td>
<td>154.6 ± 49.4</td>
<td>0.1232 ± 0.0147</td>
<td>0.0743 ± 0.006</td>
</tr>
<tr>
<td></td>
<td>40.0</td>
<td>179.1 ± 81.1</td>
<td>0.1677 ± 0.0173</td>
<td>0.1318 ± 0.017</td>
</tr>
<tr>
<td>V. panoptes</td>
<td>20.5</td>
<td>2005 ± 338</td>
<td>0.0274 ± 0.0025</td>
<td>0.0232 ± 0.002</td>
</tr>
<tr>
<td></td>
<td>30.6</td>
<td>2003 ± 383</td>
<td>0.0889 ± 0.0060</td>
<td>0.0679 ± 0.005</td>
</tr>
<tr>
<td></td>
<td>35.3</td>
<td>1427 ± 375</td>
<td>0.1200 ± 0.0149</td>
<td>0.0930 ± 0.010</td>
</tr>
<tr>
<td></td>
<td>40.0</td>
<td>799 ± 308</td>
<td>0.2057 ± 0.0411</td>
<td>0.1588 ± 0.033</td>
</tr>
</tbody>
</table>

The relationships between the mass-specific SMR \( (\dot{V}O_2 \text{ and } \dot{V}CO_2) \) and \( T_s \) for the two species are best represented by the following equations: for \( V. gouldii \), \( \log_{10} \dot{V}CO_2 \text{ (ml g}^{-1} \text{h}^{-1}) = -2.43 (±0.139) + 0.037 (±0.0042) T_s, \) \( (r = 0.89; n = 22) \), and \( \log_{10} \dot{V}O_2 \text{ (ml g}^{-1} \text{h}^{-1}) = -2.13 (±0.17) + 0.033 (±0.005) T_s, \) \( (r = 0.88; n = 22) \); for \( V. panoptes \), \( \log_{10} \dot{V}CO_2 \text{ (ml g}^{-1} \text{h}^{-1}) = -2.53 (±0.0972) + 0.043 (±0.0033) T_s, \) \( (r = 0.92; n = 32) \), and \( \log_{10} \dot{V}O_2 \text{ (ml g}^{-1} \text{h}^{-1}) = -2.49 (±0.096) + 0.045 (±0.005) T_s, \) \( (r = 0.93; n = 32) \); intercept and slope values are mean \( ±SE \). The Q\(_{10}\) values determined from the average \( \dot{V}O_2 \) values were for \( V. gouldii \), 1.68 between 20 C and 30 C and 2.64 between 30 C and 40 C; for \( V. panoptes \), 3.21 between 20 C and 30 C and 2.44 between 30 C and 40 C. Q\(_{10}\)'s for the
Table 2. Relationship between log_{10} VCO₂ and log_{10} VO₂ (ml/h) with log_{10} Body Mass (g) at 20 C, 30 C, 35 C, and 40 C for Combined Data for Varanus gouldii and V. panoptes; Equations Are of the Form log_{10} VCO₂ = a + b log_{10} Mass. Values are $a \pm SE$ and $b \pm SE$ from the regression equation, with the correlation coefficient (r) and sample size in parentheses. Body masses as in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>VCO₂</th>
<th>VO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>$-1.77 \pm 0.156$</td>
<td>$-1.40 \pm 0.15$</td>
</tr>
<tr>
<td>b</td>
<td>$1.039 \pm 0.053^{a,b}$</td>
<td>$0.948 \pm 0.0511^{a,b}$</td>
</tr>
<tr>
<td>r</td>
<td>0.982 (16)</td>
<td>0.980 (16)</td>
</tr>
<tr>
<td>30 C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>$-1.55 \pm 0.075$</td>
<td>$-1.52 \pm 0.15$</td>
</tr>
<tr>
<td>b</td>
<td>$1.118 \pm 0.0472^{a,b}$</td>
<td>$1.146 \pm 0.052^{a,b,c}$</td>
</tr>
<tr>
<td>r</td>
<td>0.988 (15)</td>
<td>0.987 (15)</td>
</tr>
<tr>
<td>35 C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>$-1.35 \pm 0.10$</td>
<td>$-1.05 \pm 0.15$</td>
</tr>
<tr>
<td>b</td>
<td>$1.102 \pm 0.039^{a,b,c}$</td>
<td>$1.05 \pm 0.059^{a,b}$</td>
</tr>
<tr>
<td>r</td>
<td>0.992 (14)</td>
<td>0.982 (14)</td>
</tr>
<tr>
<td>40 C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>$-0.97 \pm 0.21$</td>
<td>$-0.84 \pm 0.108$</td>
</tr>
<tr>
<td>b</td>
<td>$1.042 \pm 0.088^{a,b}$</td>
<td>$1.037 \pm 0.075^{a,b}$</td>
</tr>
<tr>
<td>r</td>
<td>0.976 (9)</td>
<td>0.982 (9)</td>
</tr>
</tbody>
</table>

* Slope is significantly different from 0.0 ($P < 0.05$).
* Slope is significantly different from 0.75 ($P < 0.05$).
* Slope is significantly different from 1.00 ($P < 0.05$).

Two species between 20 C and 30 C were 2.64 and between 30 C and 40 C, 2.32.

Relationship between metabolism, body mass, and temperature.—The multiple regression equations that predict SMR for the two species examined using the independent variables of body mass and $T_s$ are given in Table 3.

Discussion

The diurnal pattern of VO₂ reported by Wood et al. (1978) for V. exanthematicus was apparent for many of the varanids examined in this study, with the lowest levels of VO₂ and VCO₂ most often recorded from 2400—0800 h. Only these minimal values of VO₂ and VCO₂ are considered here to be the SMR. Consequently, these values are expected perhaps to be lower than SMRs reported in other studies using less stringent methodology (e.g., closed respirometry) or selection of minimal values. Nevertheless the mass-specific SMR of V. panoptes and V. gouldii at 20 C (Table 1) are similar to or slightly higher than resting values reported by Bartholomew and Tucker (1964), Bennett (1972), and SMR values reported by Earll (1982) for other large varanids. At 35 C, the SMR for the species studied here are similar to resting values reported by Bennett (1972) for V. gouldii and V. rosenbergi and SMR values reported by Wood et al. (1977a, 1977b) for V. exanthematicus but are lower than

![Fig. 1. Oxygen consumption and carbon dioxide production for Varanus gouldii (a) and V. panoptes (b). Means and two standard errors shown.](image-url)
Table 3. Relationship between $\text{VCO}_2$ and $\text{VO}_2$ (ml/h), Body Mass (M) and $T_b$ from 20–40°C for Varanus gouldii and V. panoptes. Equations are in the form of log$_e$ SMR = $a + b \log_10$mass + $cT_b$, with the correlation coefficient (r) and number of observations in parentheses.

<table>
<thead>
<tr>
<th></th>
<th>$a$</th>
<th>$b$</th>
<th>$c$</th>
<th>r (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>V. gouldii</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{V}_0$</td>
<td>−2.30 ± 0.2014</td>
<td>1.11 ± 0.0777</td>
<td>0.0317 ± 0.004947</td>
<td>0.97 (7)</td>
</tr>
<tr>
<td>$\text{VCO}_2$</td>
<td>−2.62 ± 0.1617</td>
<td>1.12 ± 0.06299</td>
<td>0.0358 ± 0.003972</td>
<td>0.97 (7)</td>
</tr>
<tr>
<td><strong>V. panoptes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{V}_0$</td>
<td>−2.89 ± 0.2267</td>
<td>1.11 ± 0.05904</td>
<td>0.0466 ± 0.005202</td>
<td>0.97 (12)</td>
</tr>
<tr>
<td>$\text{VCO}_2$</td>
<td>−2.81 ± 0.2381</td>
<td>1.08 ± 0.06201</td>
<td>0.0439 ± 0.00363</td>
<td>0.96 (12)</td>
</tr>
<tr>
<td><strong>Combined data</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{V}_0$</td>
<td>−2.47 ± 0.1304</td>
<td>1.04 ± 0.02931</td>
<td>0.0408 ± 0.002807</td>
<td>0.98 (19)</td>
</tr>
<tr>
<td>$\text{VCO}_2$</td>
<td>−2.70 ± 0.1148</td>
<td>1.07 ± 0.02581</td>
<td>0.0409 ± 0.002471</td>
<td>0.99 (19)</td>
</tr>
</tbody>
</table>

The resting values reported by Bartholomew and Tucker (1964) for four species of Australian varanids, by Louw et al. (1976) for V. albicularius, by Mitchell et al. (1981) for V. exanthematicus, and by Gleeson (1981) for V. salvator.

$\text{VCO}_2$ has been less frequently reported than $\text{VO}_2$ for varanids. The results of this study concurred closely with those reported by Wood et al. (1977a, 1977b) for V. exanthematicus but are lower than those reported by Gleeson (1981) for V. salvator, by Mitchell et al. (1981) for V. exanthematicus, and by Mitchell and Gleeson (1985) for V. salvator at 35°C.

The RQ varied between 0.63 and 0.83 for V. gouldii over the $T_b$ range of 20–40°C; it was relatively more constant with the range of 0.76–0.84 for V. panoptes. These values are within the range reported for other lizards (Bennett and Dawson, 1976) and other varanids [0.68 at 35°C by Mitchell et al. (1981), 0.63 at 25 and 35°C by Mitchell and Gleeson (1985), and 0.73 at 35°C by Gleeson and Bennett (1982)].

**Interspecific allometry.**—There were some significant differences in $\text{V}_0$ and $\text{VCO}_2$ values for V. gouldii and V. panoptes (e.g., mass-specific $\text{VCO}_2$ of V. panoptes was significantly different from that for V. gouldii), but there was no difference in the scaling exponent for $\text{V}_0$ of the species ($\beta = 1.11$) or $\text{VCO}_2$ ($\beta = 1.10$). These $b$ values are appreciably higher than those reported by Bartholomew and Tucker (1964) for four species of Australian varanids (0.82 at 30°C). They are also much higher than the mass exponent calculated for all lizards by Andrews and Pough (1985) of 0.80 (SE ± 0.012), values given by Bennett and Dawson (1976), and the value of 0.75 generally used to describe the relationship of SMR and body mass for different taxonomic groups (Blaxter, 1989).

The allometric equations at 35°C calculated by Wood et al. (1978) for V. exanthematicus (172–7500 g) and Andrews and Pough (1985) for all squamates are appreciably different from the data from this study (Fig. 2). The high $b$ value for all varanids reported here (1.11) is due to the lower-than-expected SMR of the small V. gouldii and the higher-than-expected $\text{V}_0$ of the large V. panoptes (Fig. 2). Such high $b$ values are unusual but not without precedent. Galvao et
Fig. 2. The relationship of absolute oxygen consumption to body mass at 35°C for Varanus exanthematicus (Wood et al., 1978), all squamates (Andrews and Pough, 1985), and V. gouldii and V. panoptes in this study.

al. (1965) report a b value of 0.98 for Colubridae and 1.09 for Boidae at 21.5°C, and Huggins et al. (1971), a b value of 0.926 over a small mass range (191–382 g) for small caimans at a T_b of 24.5°C. It is interesting to note that Dryden et al. (1990) report a mass exponent of 1.10 for field metabolic rates of three species of varanids (V. acanthurus, V. rosenbergi, and V. giganteus; mass 60–7700 g) based on the compilation of data from four studies.

**Effect of T_b on metabolic rate.**—Body temperature (T_b) has a profound effect on SMR, of the general form SMR = j 10^{k T_b}. Bartholomew and Tucker (1964) found that, for four species of Australian varanids (16–4400 g), the relationship between mass-specific VO_2 and T_b (20–40°C) was best represented by the equation: VO_2 (ml g\(^{-1}\) h\(^{-1}\)) = 0.00253 \times 10^{0.518(T_b)}. Bennett (1972) reported that the overall relationship between SMR and mass for V. gouldii and V. rosenbergi (139–1280 g) [VO_2 (ml g\(^{-1}\) h\(^{-1}\)) = 0.000147 \times 10^{0.197(T_b)-0.00195(T_b)^2}] was linear for the semilogarithmic relationship between SMR and T_b from 15–30°C but that SMR was independent of T_b from 30–40°C. No evidence of a plateau effect for VO_2 as reported by Bennett (1972), or VCO_2, was apparent between 30°C and 40°C for either of the two species of varanid studied here (Fig. 1). The value of k is 0.083 for VO_2 of V. gouldii, and 0.045 for VO_2 of V. panoptes; these k values are significantly different. For VCO_2, k = 0.037 for V. gouldii and 0.043 for V. panoptes; these are not significantly different. Earll (1982) found a simple nonlogarithmic relationship between VO_2 and T_b for V. bengalensis between 20°C and 40°C, represented by the equation VO_2 (ml g\(^{-1}\) h\(^{-1}\)) = 0.00304T_b – 0.03612 (n = 3, r = 0.96).

The Q_10 generally declines with increasing T_b (from 20–40°C), but there are many exceptions...
to this pattern of thermal dependence (Bennett and Dawson, 1976). $Q_{10}$ values are similar at 2.6 and 2.3 for all varanids in this study, for $T_a$'s of 20–30 C and 30–40 C. Wood et al. (1977b) report a $Q_{10}$ of 2.15 for $V. exanthematicus$ between 25 C and 35 C, Bennett (1972) a $Q_{10}$ of 1.07 between 35 C and 40 C for $V. gouldii$. Bartholomew and Tucker (1964) a $Q_{10}$ of 3.30 between 20 C and 40 C for $V. gouldii$, and Earl (1982), reported $Q_{10}$ values of 1.91 from 20–30 C; for $V. bengalensis$ the reported $Q_{10}$ values were 1.74 from 30–40 C and 1.82 from 20–40 C.

Species comparisons.—After extensively reviewing the data for VO$_2$ of lizards, Andrews and Pough (1985) gave the following general equation to predict the oxygen consumption rate of lizards, taking into account body temperature, body mass, and the lizards' metabolic state: VO$_2$ (ml/h) = 0.013 g$^{0.80}$ 10$^{0.038(T_b)}$ 10$^{1.14(m)}$ (where ms = metabolic state; 0 = standard, 1 = resting). The corresponding regression equations that predict SMR for the two species of varanid examined in this study have a different mass coefficient but similar temperature coefficient: VO$_2$ (ml/h) = 0.00646 g$^{0.98}$ 10$^{0.038(T_b)}$; and VCO$_2$ (ml/h) = 0.00365 g$^{0.92}$ 10$^{0.038(T_b)}$. However, it should be kept in mind that these equations are only a generalization for the highly significant effects of body mass (80.4% of total variance) and temperature (15.9% of total variance) on metabolic allometry of varanid lizards; there are minor, though statistically significant, differences in allometry of SMR for the two species studied here.

Acknowledgments

The assistance of the W. A. Museum in identifying $V. panoptes rubidus$ was appreciated. The help of S. Thompson on field trips is also acknowledged and appreciated. Animal experimentation was done with the approval of the Animal Welfare Committee of the University of Western Australia. All varanids were caught and held under license issued by the Department of Conservation and Land Management. We thank E. R. Pianka for providing us with a small $V. gouldii$.

Literature Cited


DEPARTMENT OF ZOOLOGY, UNIVERSITY OF WESTERN AUSTRALIA, NEDLANDS, 6009, AUSTRALIA. Accepted 13 May 1991.

Monophyly and Relationships of the Argentinoid Fishes

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Evidence of monophyly and relationships of the Argentinoidei is provided, based on a phylogenetic analysis including argentinoids, osmeroids, and other euteleosts. The Argentinoidei is monophyletic and is composed of two monophyletic clades, Argentinoidea and Alepocephaloidea. The evidence for monophyly of the Argentinoidei is largely drawn from anatomy of the branchial basket, and other potentially corroborating evidence is presented. The Argentinoidea is monophyletic. In this analysis, bathylagids are the sister taxon of opisthoproctids, argentinids the sister of these two. The Alepocephaloidea, usually composed of three to four families, is restricted here to a single family, Alepocephalidae. The highly derived Platyrroctidae is more closely related to some alepocephalids than others, and is not recognized as a separate family. The monotypic Bathyaconidae, Bathypriornidae, and Leptochilichthyidae are not recognized, because doing so would both obscure the shared history of these taxa and render the Alepocephalidae paraphyletic.

The sister taxon of the Argentinoidei is the Osmeroidei. Together they comprise the Osmerae. Previous hypotheses have placed either the Salmonidae or the highly derived galaxioid Lepidogalaxias as the sister taxon of the Neoteleostei. It is hypothesized here that the Osmerae is the sister taxon of the Neoteleostei on the basis of two synapomorphies: presence of a postmaxillary process of the premaxilla and loss of laminar bone on the anterior margin of the hyomandibula. The relationships of other euteleostean clades to the Osmerae and Neoteleostei are as yet unresolved.

BEFORE 1971, the argentinoid and alepocephaloid fishes (sensu Greenwood et al., 1966) had not been grouped together. Both groups had instead been variously associated with clupeoid or even salmonid fishes. In 1971, Greenwood and Rosen first recognized what they believed to be evidence of common ancestry between argentinoids and alepocephaloids. This was drawn largely from a unique branchial structure, the crumenal organ. Located at the posterolateral portion of the branchial basket, the crumenal organ is an outpocketing of the posterior pharynx, supported by specialized branchial skeletal elements. Unlike other epi-

branchial organs (Nelson, 1967), the crumenal organ has a novel element: a so-called accessory cartilage that connects the fifth ceratobranchial to the fifth epibranchial (Nelson, 1967, fig. 1H; Greenwood and Rosen, 1971, figs. 1–6). Greenwood and Rosen (1971) also considered an “argentinoid” caudal skeleton to be diagnostic of the Argentinoidei, though only one alepocephaloid (Searsia) shares the condition. On the basis of this evidence, they erected the Argentinoidei to include the Argentinoidea and Alepocephaloidea.

Since that time, there has been no new evidence for the monophyly of the Argentinoidei.

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