PLATYPUS, *ORNITHORHYNCHUS ANATINUS*, MOVEMENT DATA FROM THE DUCKMALOI WEIR POOL: POISSON REGRESSION MODELS

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McLeod (1993) monitored the movement of platypuses (*Ornithorhynchus anatinus)* using telemetric devices, recording the number of times animals were found in predetermined grid positions in a pool impounded behind the Duckmaloi Weir near Oberon, New South Wales, and the number of times they were discovered in numerous burrows on the periphery of the weir pool. The aim of this program was to identify the predictive variables that accounted for platypus movement from among those measured such as water depth, and from among known factors such as age. A Poisson regression model is described together with the results for these data. The potential benefits of Poisson regression models for these data over log transformation models, such as handling zeros and catering for overdispersion, are expounded. The analyses indicate that the use of areas of the weir pool were related to water depth, with there being greater use of shallow depths in the channel than in other locations in the pool. There was also differential usage of burrows in the banks of the pool related to different degrees of foliage density from one side of the weir pool to the other.

Key words: platypus, *Ornithorhynchus anatinus*, movements, Poisson regression

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MCLEOD (1993) monitored movement patterns of platypuses *(Ornithorhynchus anatinus)* using telemetric devices in a pool impounded behind the Duckmaloi Weir (weir pool), near Oberon, New South Wales, recording the number of times animals were found in predetermined grid positions on the pool during presumed feeding forays, mainly between dusk and dawn. McLeod (1993) also determined the number of times *O. anatinus* were discovered in numerous burrows or burrow complexes on the periphery of the weir pool. A range of supplementary habitat measurements were also taken. This paper specifically aims to explain the pattern of distribution of animals in the weir pool and in adjacent burrows in terms of environmental variables.

METHODS

The study site is a pipehead weir impoundment on the Duckmaloi River, which is designed to offtake water to increase security of supply for the Fish River system on the central tablelands of New South Wales. The dammed water effectively behaves as a medium size river pool, approximately 2.5 ha in surface area. A population of *O. anatinus* utilise the river adjacent to the weir (Goldney 1998). *Ornithorhynchus anatinus* were trapped using unweighted gill nets (Grant and Carrick 1974) and transmitters were attached to the tails of 17 animals (two juvenile, one subadult and two adult females, eight juvenile, one subadult and three adult males (McLeod 1993)). Transmitters remained on the animals for periods ranging from 3 weeks to 8 months. Some lost transmitters were replaced. Radio tracking occurred over an eight month period in 1993. A total of 450 hours were spent radio tracking animals averaging 12 to 15 hours per week. One hundred and ninety six hours were spent studying movement and activity on the weir, and 90 hours locating burrow complexes. The weir pool was divided into a 20m grid system and animal positions were plotted within this grid system. Time and activity were recorded simultaneously, together with the grid reference location. A Telonics TR-2/TR-1 scanner receiver and a TR-1 receiver were used in conjunction with a hand held H antenna for animal location and activity (McLeod 1993).

Poisson regression modelling

Poisson data can arise when a response is *discrete*, for example, the number of animals recorded per unit area or over a fixed period of time. The theoretical distribution is described graphically (Figs 1, 2) for different response levels. The first (Fig.1) is more right skewed than the second (Fig. 2), and has smaller variance.

The presence of zeros in Fig. 1 is typical of this type of count data and cannot be ignored. What is presented here is an alternative to log transformation of the count data, for example log(c+1), which may work in situations such as that illustrated in Fig. 2, but can produce strange results in cases described by Fig. 1. For example, if there are a high proportion of zeros the transformation can produce multimodal data. One objective of Poisson regression analysis is to explain differences such as those shown between Figs 1 and 2 using known predictors, such as the age of animals, with habitat and environmental measures. The models used are of the type

response = model + noise

where 'model' is a function of a linear combination of the predictors - i.e., a *generalised linear model*. The Poisson response is described by the discrete distribution

$$P(Y = y) = e^{-\lambda}\lambda^{y}/y! \quad y = 0, 1, 2......$$

where Y is the variable giving the recorded number of animals per unit area or time, whose mean rate is given by the parameter λ. The modelling of the data is achieved by fitting to the count data the relation:

$$\lambda = e^{\text{linear model}}$$

where 'linear model' is simply a model using predictive variables as for a linear regression model assuming Normal errors. The *deviance* is a discrepancy measure of the departure of the model from the data - ie. large values of the deviance indicate a poor fit while low values are a sign of well modelled data. For Poisson data the mathematical form of the deviance is

$$2\Sigma\, y\, ln\, (y/f)$$

where the observed data are values *y*, and the fitted response are values *f*. This quantity is analogous to least squares since it satisfies the previous description of a discrepancy measure, as does least squares for Normal data. The yardstick for determining model adequacy is that changes in the deviance are approximated by the chi-square distribution (χ^2). For the theoretical Poisson model, the variance of the response is equal to its mean. This has been shown empirically in Figs 1 and 2, where increasing the mean led to an increased variance. In applications the variance of the response can vary by orders of magnitude from the mean due to a phenomenon called *overdispersion.*

This is handled by assuming that

$$Var(Y) = \sigma^2 E(Y)$$

and estimating the overdispersion (σ^2) by the mean deviance or its equivalent. Tests have to be adjusted to allow for the fact that $\sigma^2 \neq 1$.

RESULTS

In both the studies described below, only one female animal was recorded consistently throughout, giving a gender imbalance that disallowed the use of sex as a predictor of animal abundance.

Study of movements in water

The number of *O. anatinus* found in predetermined grid positions in the weir pool system was recorded via the use of a tracking device. The predictor variables measured were: Age (Adult or Juvenile), Water Depth, Sediment Depth and Location (in the channel, middle and upstream of the weir pool).

Fitting Poisson regression models to the data yielded the analysis of deviance shown in Table 1. All other effects were non significant ($\chi^2_{1,5\%} = 3.84$, $\chi^2_{2,5\%} = 5.99$).

Effect	Change in Deviance	Degrees of Freedom
Age	137	1
Sediment depth	61	1
Water depth	93	1
Location	59	2
Water depth by location	16	2

Table 1. Analysis of deviance showing all effects presented as clearly significant except for the interaction of water depth with location, which could be taken to be marginal due to the presence of overdispersion. The change in deviance given for each variable reflects the adding of that variable to model. A small change in deviance indicates a poor predictor.

The model reduced variability to 50% of its original value, with the estimate of overdispersion dropping from 9.64 to 4.76. The effects above suggest a simple *additive* relation between the abundance of platypuses and the measures recorded apart from the interaction of water depth with location. All other effects can be considered to act independently. Fig. 3 shows the interaction between location and water depth. In the channel, shallow water depths were preferred, whereas the reverse was true for the middle and upstream locations, where the animals preferred deeper sections to shallow ones.

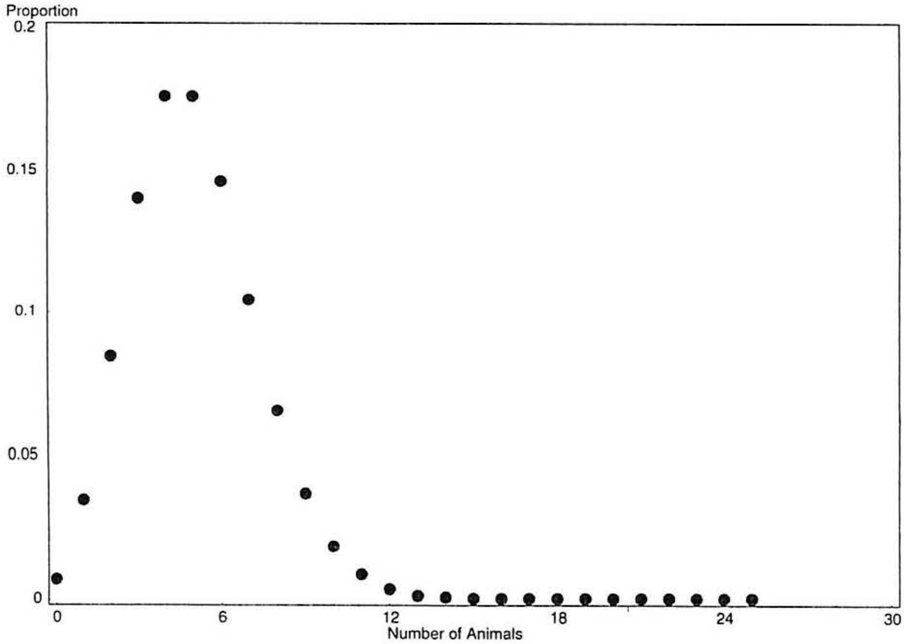

Fig. 1 The theoretical distribution shown is for a Poisson population having an average of 5 animals per unit area or per unit time. The distribution is centred on the population mean (5), but is skewed to the right and contains a proportion of zeros, explaining the skewness.

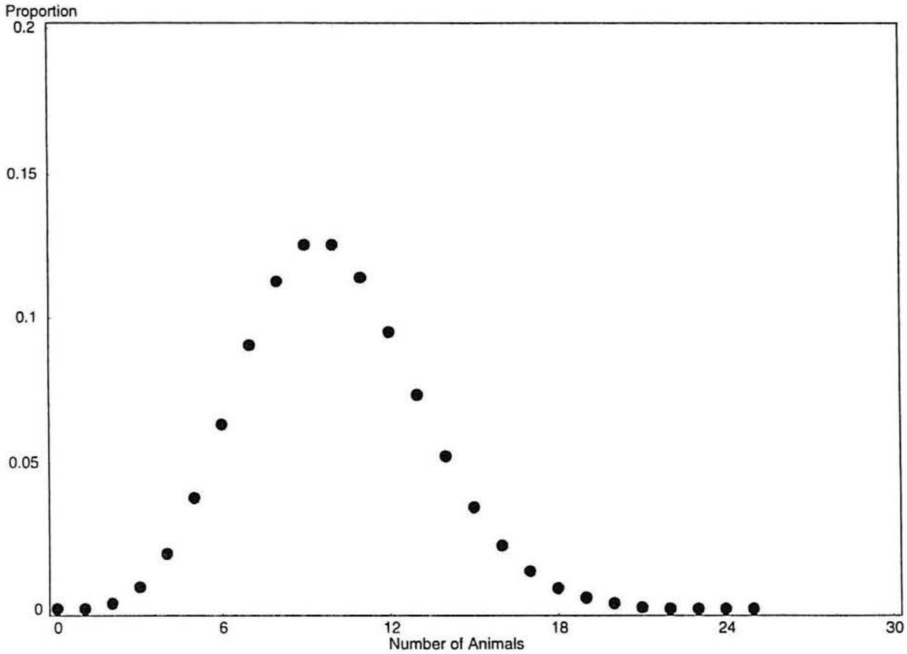

Fig. 2. The theoretical distribution shown is for a Poisson population having an average of 10 animals per unit area or per unit time. In contrast to Fig. 1, this distribution is more symmetrical, in which case an approximation by the Normal distribution would be more reasonable than for the situation in Fig. 1.

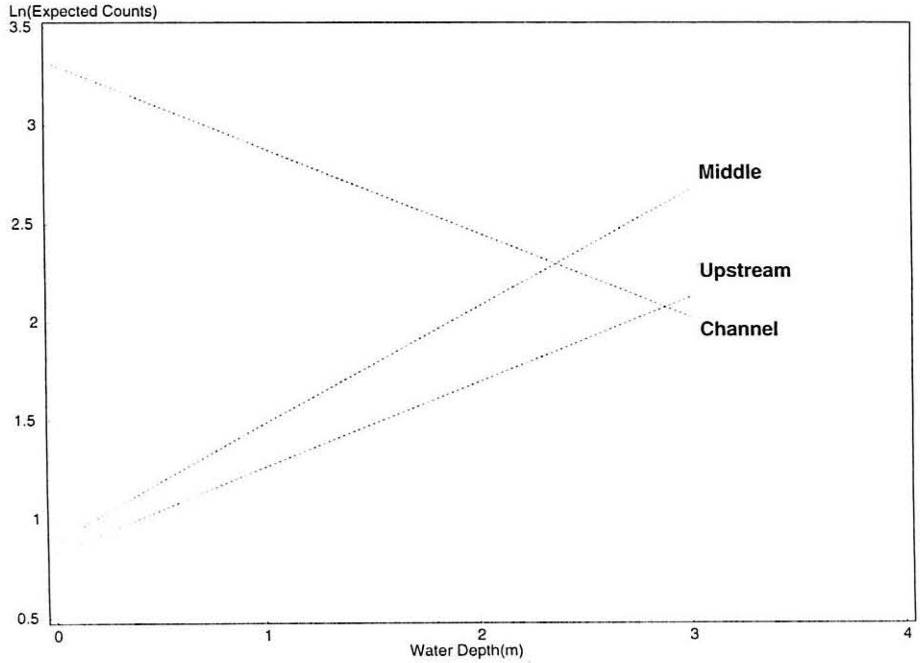

Fig. 3. The interaction between location and water depth as shown in Table 1 demonstrates that response to water depth in the channel is different from the response to water depth in the middle and upstream locations.

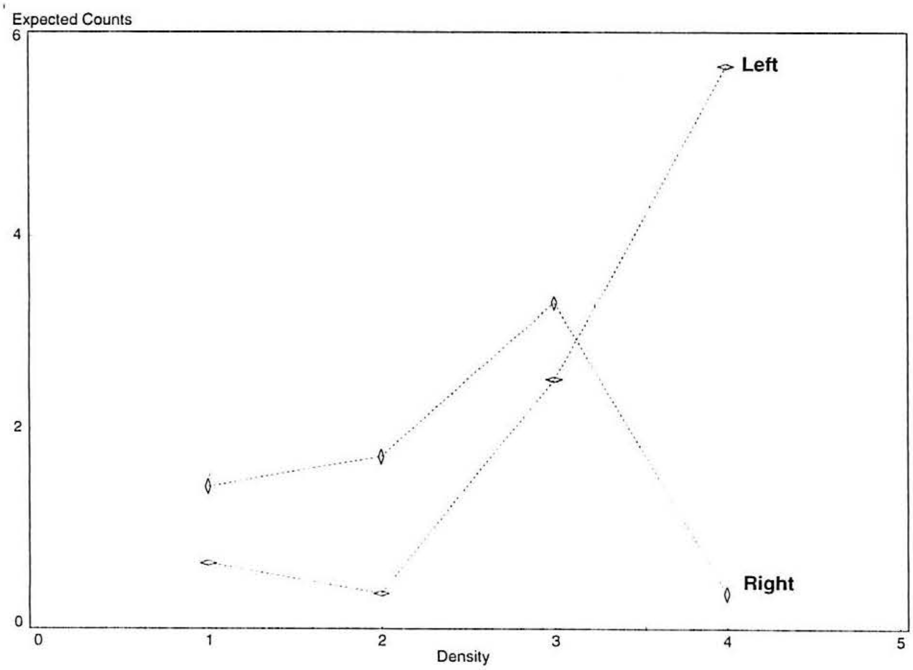

Fig. 4. The interaction between the side of the weir pool and the density of overhanging vegetation, as shown in Tables 2 and 3, demonstrates that the western side (right) is preferred for all levels of density of vegetation except the most dense.

Study of burrow usage

The number of *O. anatinus* found in burrows on the edge of the weir pool was recorded, together with bank and vegetation parameters. The following set of explanatory variables was used: Age (Adult or Juvenile), side of weir pool (east and west), density (of overhanging vegetation (none, light, moderate or dense).

Poisson regression models were fitted to these data and the results are found in Table 2. All other effects were not significant ($\chi^2_{3,5\%} = 7.82$). The model reduced the variability to 70% of its original value, as overdispersion went from 4.98 to 3.5. As age is an additive effect, the interaction of side with density can be shown by the expected counts in Table 3.

Effect	Change in Deviance	Degrees of Freedom
Age	13.4	1
Density	19.0	3
Side	6.0	1
Side Density	42.8	3

Table 2. The analysis of deviance table shows clearly the interaction of side with density, with age simply being an additive effect. A large change in deviance indicates that the variable is a useful predictor. The Left side of the pool is the eastern side and the Right side the western.

Side		Density			
		none	light	moderate	dense
Right	1	1.4	1.7	3.3	0.3
Left	2	0.6	0.3	2.5	5.7

Table 3. The fitted values from the model show the interaction of side with density by comparing the response to side at the dense level to all the other levels of density (none, light and moderate).

Density preference changed from west (right) to east (left) as shown in Fig. 4. The animals preferred to utilise burrows on the western side of the weir pool where the level of overhanging vegetation was low or of moderate density, but this preference was reversed where the overhanging vegetation was most dense. This means that for banks with the most dense levels of overhanging vegetation animals preferred the eastern side of the pool.

DISCUSSION

Poisson regression models have been used to successfully model two different sets of movement data for the platypus. In both studies, this regression technique has identified not only age effects, but also interactions between environmental variables that characterise platypus behaviour. The presence of overdispersion, especially in the burrow study, could be due to unmeasured variables, such as food availability, but it is probable that the animals do not act independently in both cases, as assumed by the Poisson model. It is an advantage of the Poisson regression approach that overdispersion can be estimated. A formal test of the presence of overdispersion exists (Greene 1993), but was not used in these two studies due to the large values encountered for overdispersion.

In both studies the effects of age is additive, that is it acts independently of other variables. This means that the age effect can be interpreted without qualification from any other measures. The interpretation of the age effect in both studies is that juveniles were recorded more often in the pools, or in burrows, than adults. This effect was stronger in the water depths study (88 observations) than in the burrow study (66 observations), but was qualitatively equivalent in both cases.

The analyses indicate that use of areas of the weir pool are related to water depth, with there being greater use of shallow depths in the channel than in other locations in the pool. There was also differential usage of burrows in the banks of the pool related to different degrees of foliage density from one side of the weir pool to the other. The reasons for these patterns of usage of the pool and surrounding banks are not immediately obvious but may be related to local differences in benthic productivity and possibly to the mainly easterly and westerly aspects of the two banks.

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