DUNG BEETLES IN THE WILLIAMS AND HUNTER RIVER CATCHMENTS OF NSW

A.L. Bishop[1], N.W. Griffiths[2], S. Richards[2], I.M. Barchia[1] and L.J. Spohr[1]

[1] NSW Agriculture, Locked Bag 26, Gosford, NSW, 2250
[2] NSW Agriculture, PO Box 123, Maitland, NSW, 2323

Summary

Surveys of dung beetles were conducted in the Williams and Hunter River catchments of NSW in 1997/98. The aim was to obtain information on the composition, distribution and relative abundances of those species likely to reduce the movement of pollutants from bovine dung to waterways and water storage systems. A complex of six introduced and four native species was common. Some sites were consistently associated with particular species although there were wide variations in numbers between sites. There was pronounced seasonal activity in the complex with the introduced *Onthophagus gazella* F. and *Euoniticellus intermedius* (Reiche) (plus *Onitis alexis* Klug in 1998) and the native *Onthophagus granulatus* Boheman the most abundant and active species from November to May. Activity was low at other times and was dominated by *O. granulatus*. As a result, the winter active species *Bubas bison* L. has been released to fill the largely vacant niche in the cooler months.

INTRODUCTION

A complex of dung beetles was introduced to augment the native fauna in Australia between 1968 and 1993 (Doube and Macqueen 1991; Turnbull 1992; Tyndale-Biscoe 1990). The primary aim was to reduce numbers of dung-breeding, biting flies, specifically the bush fly *Musca vetustissima* Walker (Feehan *et al.* 1985; Hughes *et al.* 1978; Ridsdill-Smith *et al.* 1986; Smith 1981) and the buffalo fly, *Haematobia exigua* de Meijere (Bornemissza 1971; Doube 1986). Dung burial has also improved agronomic conditions, promoting higher plant yield and productivity in pasture (Bornemissza and Williams 1970; Doube 1989; Edwards and Aschenborn 1987; McKinney and Morley 1975), and has been responsible for a reduction in numbers of some larval helminths affecting livestock (Bryan 1973).

Dung accumulation increases the risk of run-off carrying pollutants, including nitrates, phosphates and bacteria to waterways after rain. This problem is acknowledged by the Hunter Catchment Management Trust's concern over the Hunter and Williams Rivers which supply water to the Hunter and Greater Newcastle areas respectively. The effective removal of dung by dung beetles is seen as a possible solution. Some species of dung beetles have been released in the Hunter Region (Tyndale-Biscoe 1990, 1996), including near Dungog in the Williams Valley in the 1970's. No comprehensive follow up on the success of these releases or the establishment of other species has been made. Assessments of local complexes have only been made in Australia occasionally (Allsopp 1975, 1977; Flanagan 1991) and reduction of pollutants from dung in waterways has rarely been a major consideration of any study. A survey was undertaken to provide information on the composition, distribution and relative abundance of the existing dung beetle fauna and the need for further releases.

MATERIALS AND METHODS

Twenty-two sites (Figure 1) were sampled within the Hunter and Williams Valleys in two surveys. Samples were taken from open, grassed pastures being grazed by cattle.

The first survey (Survey 1) was conducted at nine sites (W1 to W9) along the Williams River Valley, at Tocal and Vacy in the adjacent (west) Patterson Valley and at Hinton, near Maitland in the Hunter Valley. The first sample was taken in March 1997 and then at two-monthly intervals until January 1998.

The second survey (Survey 2) was made in March 1998. Eight new sites were sampled in the mid to upper Hunter and two in the Karuah River Valley (Stroud Road and Booral) to the east of the Williams Valley. The Tocal and W1 (Seaham) sites were retained.

Twenty fresh (1–2 days old) bovine dung pats and the dirt immediately below the pats were collected at random and placed individually into 20 L plastic buckets at each site on each sampling occasion. Beetles were extracted by the flotation method (Houston *et al.* 1982) and stored for counting in plastic jars containing 70% alcohol. Counts and separation into species were made in the laboratory under a binocular dissecting microscope.

Analysis of data

Data were analysed to describe and compare the distributions of the seven most common species of dung beetles (Table 1) at the 12 sites in each survey for each sampling occasion. No comparisons were made between times. Significant correlation between

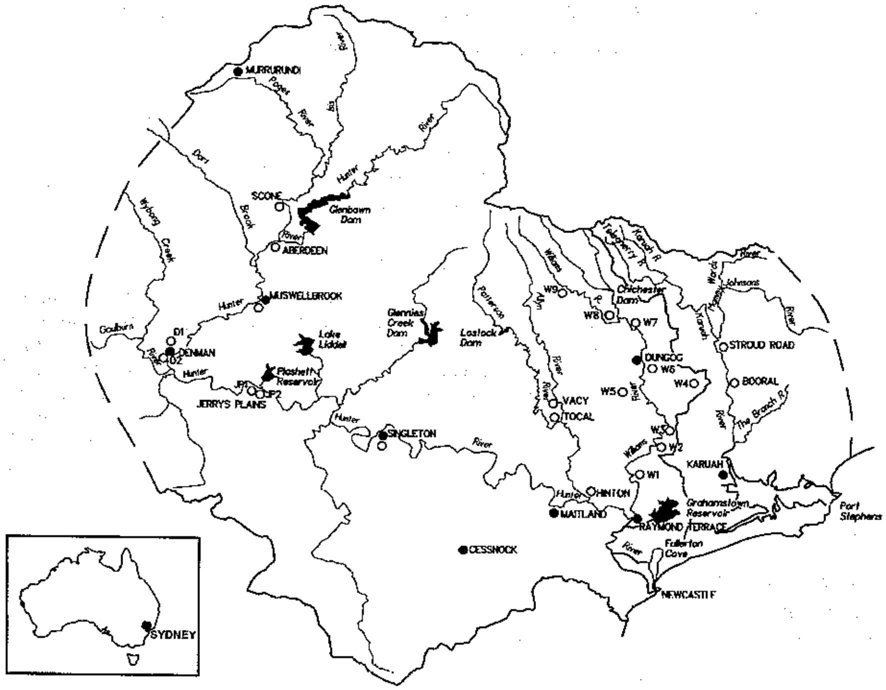

Figure 1. Location of dung beetle sampling sites (open circles) in the Williams Valley and Hunter Region of NSW (see insert) in 1997/98.

Table 1. Species of beetles associated with dung in the Williams and Hunter River Valleys as defined by Tyndale-Biscoe (1990).

Introduced dung beetles	Native dung beetles	Beetles other than dung beetles
Euoniticellus africanus (Harold)	*Onthophagus australis* Guérin-Méneville*	*Aphodius fimetarius* L.
Euoniticellus intermedius (Reiche)*	*Onthophagus capella* Kirby	*Aphodius (Nialus) pseudolividus* Balthasar
Hister nomas Erichson†	*Onthophagus dandalu* Mathews	*Heteronychus arator* (F.)
Onitis alexis Klug*	*Onthophagus granulatus* Boheman*	*Proctophanes sculptus* Hope
Onthophagus binodis Thunberg*		*Sporidium* sp
Onthophagus gazella F.*		

* The most abundant species and those included in the statistical analysis.
†Not a true dung beetle.

some species led to the use of the Principal Component (PC) analysis with the eigen-value (PC variance) and eigen-vector (PC coefficients) estimated from the variance-covariance structure. Two PC's explained most of the variance. The first PC (PC1) represented the relative abundance of the seven dung beetles. The second PC (PC2) represented the contrast between the groups of species. Counts were transformed to a logarithmic scale ($\log [x + 0.1]$) to normalise the distribution of data enabling us to make inferences about the populations. Confidence regions (95%) were calculated for each site (Seal 1964) and associations between sites and species determined using Bi-plot analysis (Gabriel 1971). The Bi-plot presents both PC axes as well as the original variate (species) axes. The relative (numerical) importance of the species in each bimonthly sample increased with the length of the arrows in Figures 2 and 3. Orientation of the arrows was determined by the sign of the principal equation coefficients and indicated the association between species and sites.

RESULTS

Five introduced and four native species of dung beetle plus the introduced, carnivorous *Hister nomas* Erichson were common in dung in the Williams and Hunter Valleys (Table 1). Seven of these species were in sufficient numbers to be analysed. Five non-dung beetles from an even larger complex of beetles were also common (Table 1) while three other native dung beetles were only recorded occasionally and are not included.

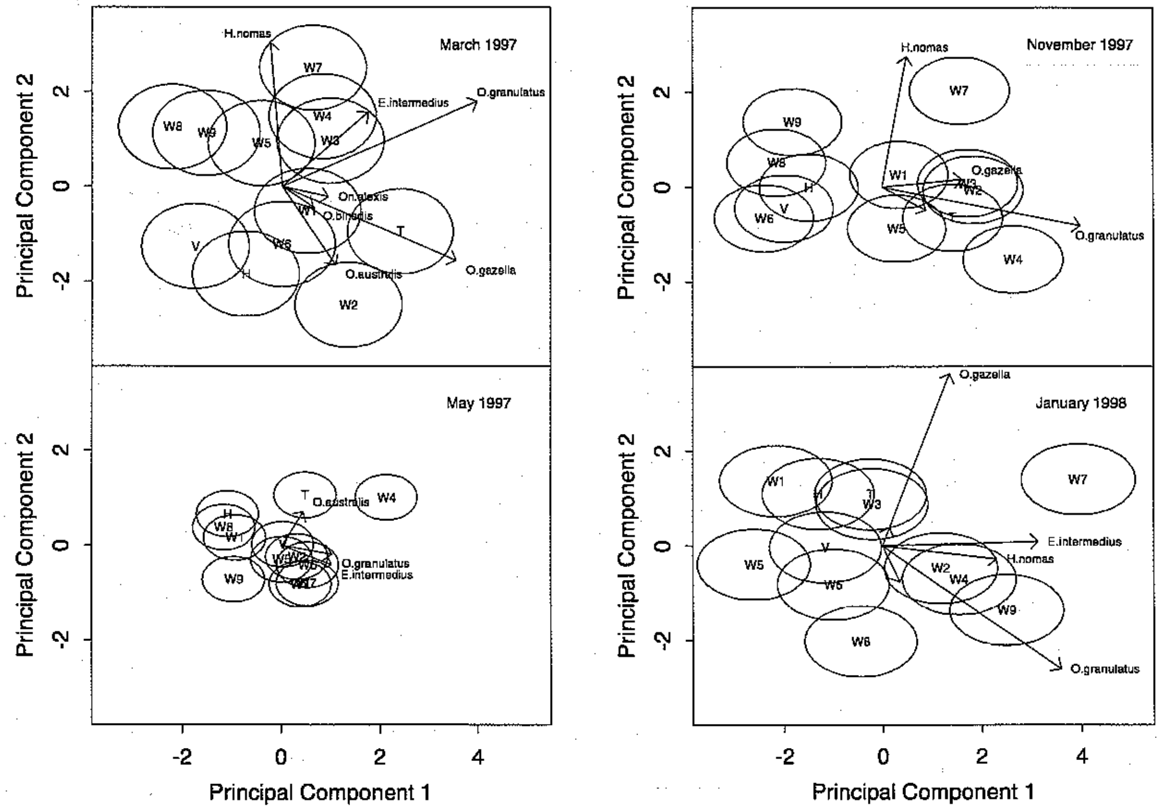

Figure 2. Association between seven species of dung beetle and nine sites in the Williams Valley (W1 to W9); Tocal (T) and Vacy (V) in the Patterson Valley; and Hinton (H) in the Hunter Valley in 4 bimonthly samples in 1997/98. The length of the arrows indicates the numerical importance of the species at each sample. The orientation of the arrows indicates the association between species and sites.

Survey 1

The first two PCs in each analysis accounted for between 54 and 65% of the variance. The total variance was lowest and the PC scores tightest in May (Figure 2). Counts were more variable in March 1997, November 1997 and January 1998.

Tocal had the highest overall count of dung beetles in March 1997 and was separated by its association with *Onthophagus (O.) gazella* F., *O. binodis* Thunberg and *Onitis (On.) alexis* Klug. Site W2 was segregated by its greater association with *O. australis* Guérin-Méneville. Site W7 was highest on the PC2 axis primarily because of its association with *H. nomas* as were sites W8 and W9. *Euoniticellus intermedius* Reiche and *O. granulatus* Boheman were dominant at sites W3 and W4. There were wide and unrelated variations in dung beetle numbers at the other sites. Vacy and Hinton were low on the PC1 and PC2 axes as a result of low counts overall.

Each species was present in May but most sites were clustered because of the domination of *O. granulatus* in the complex. Site W4 was separated because it had the highest incidence of *O. granulatus* and *E. intermedius*. Tocal retained moderate numbers of *O. granulatus* and was separated by its association with the highest number of *O. australis*.

There were too few dung beetles to analyse in July and September. Low numbers of *E. intermedius*, *O. granulatus* and *H. nomas* were recorded only at sites W2, W4, W7, and W8 in July. *O. granulatus*, *H. nomas* and *O. australis* were present in September with *O. granulatus* the most abundant species. Site W4 and Tocal were the sites with greatest activity by *O. granulatus*.

O. granulatus was still the dominant species in November although all species were present and *H. nomas* and *O. gazella* had greatly increased in number. Site W4 had the highest score on the PC1 axis due to high numbers of *O. granulatus, O. gazella* and *E. intermedius*. Site W7 was highest on the PC2 axis and was characterised by high numbers of *H. nomas*. Sites W8 and W9 were also mainly associated with *H. nomas* although, with sites W6, Vacy and Hinton, they had low dung beetle activity.

By January 1998, *E. intermedius* and *O. gazella* had increased in number and, with *H. nomas*, were dominant species at site W7. Sites W2, W4 and W9 were similar in number and species composition, and were characterised by the high numbers of *O. granulatus, H. nomas* and *E. intermedius*. The remaining sites each had low to moderate and variable numbers of the different species of dung beetle.

Survey 2

The cumulative variance of the first and second PC's was 68%. Jerry's Plains (JPl) had the highest number of dung beetles overall and was separated by its association with *On. alexis, O. intermedius* and *O. gazella* (Figure 3). Conversely, the second site at Jerry's Plains (JP2) had low dung beetle activity. Tocal was the second highest site overall and was separated from JPl by its additional association with *O. granulatus* and highest numbers of *O. gazella.* Booral and Stroud Road in the Karuah Valley were highest on the PC2 axis and had the highest numbers of *O. granulatus* and *H. nomas.* Low to moderate and variable numbers of each of the dung beetles were recorded at the other sites.

DISCUSSION

Records show that *Euoniticellus africanus* (Harold), *E. intermedius, On. alexis, O. binodis, O. gazella, O. nigriventris* d'Orbigny, *O. taurus* Schreibers, *H. nomas* and *H. cruentus* Erichson had each been released in the Hunter region (Tyndale-Biscoe 1990, 1996). *O. gazella, E. intermedius* and *O. binodis* were released near Dungog in the Williams Valley. Only *O. nigriventris* was released at Tocal. *O. nigriventris, O. taurus* (more likely to be found associated with

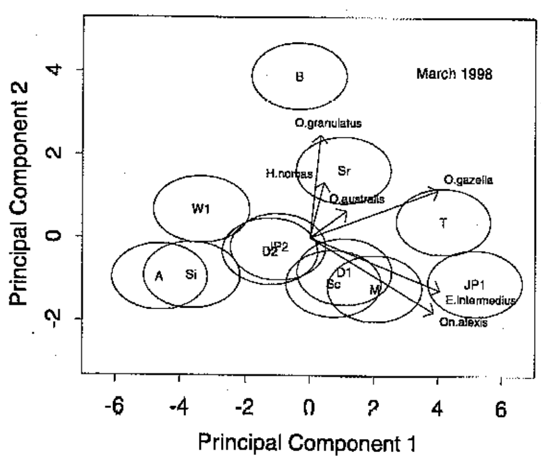

Figure 3. Associations between seven species of dung beetle at Aberdeen (A), Denman (D1 & D2), Jerry's Plains (JP1 & JP2), Scone (Sc), Muswellbrook (M) and Singleton (Si) in the mid-upper Hunter; Tocal (T) in the Patterson Valley; Seaham (W1) in the Williams Valley; and Stroud Road (Sr) and Booral (B) in the Karuah Valley in March 1998. The length of the arrows indicates the numerical importance of the species. The orientation of the arrows indicates the association between species and sites.

canine dung), and *H. cruentus* were not found in our survey or by Tyndale-Biscoe (1996). Few *E. africanus* were found in the Williams Valley. *E. africanus* was released in the mid Hunter region (Tyndale-Biscoe 1996) where its highest numbers were recorded in Survey 2. *O. australis, O. capella* Kirby, *O. chepara* Mathews, and *O. granulatus* were common native species recorded previously (Tyndale-Biscoe 1990). Of these species, *O. granulatus* and *O. australis* were dominant in our study. One notable exception from Tyndale-Biscoe (1990) was the relatively frequent, low density presence of *O. dandalu* Mathews (Table 1), not reported or apparently expected in the Hunter Region.

The species composition appears to have been relatively stable since the late 1970's when most of the releases were made. However, those species that established have not done so uniformly. Effective dung burial may therefore vary within the Hunter and its tributary valleys and even between farms in the same area (eg. Jerry's Plains). Some sites in Survey 1 were consistently associated with species less abundant elsewhere. *H. nomas* was more abundant at the upper end of the Williams Valley (sites W7, W8 and W9); and *E. intermedius* was more abundant at site W4. Differences could not be accounted for easily. Secondary releases by farmers, local environmental conditions, soil type, stock density, dung availability, dung quality, farm management (eg. harrowing) and other factors (eg. predation by birds) could have affected numbers of dung beetles and were not accounted for in the surveys.

The analysis showed that *H. nomas* and *O. granulatus* were the only species present for most of the year. *H. nomas* is not a true dung beetle and was introduced to control problem flies directly as it is predatory on fly larvae in both its adult and immature stages. It does not bury dung and is probably unimportant in the context of this study. *O. granulatus* is a cosmopolitan species adapted to dung from native animals and, by itself, is not regarded as effective against large volumes of dung from introduced livestock. The effective disposal of dung occurred between November and May during which time 98.9% of the dung beetles were recorded and *O. gazella, E. intermedius* and *On. alexis* comprised 57% of the total numbers. Dung beetles were therefore mainly active for about 5 months around summer in the Hunter region. Potential problems from the accumulation of dung increased in the remaining period (Roach 1997). There was a distinct need for species that are active at lower temperatures. As a result of this survey, climate matching has been undertaken (J. Feehan, personal communication), the winter active *Bubas bison* L. has been released and its establishment and success will be monitored. Other species with activity in winter may be released if they become available. Filling of the largely vacant winter niche should not increase competition with or cause displacement of the existing dung beetle fauna and could provide effective dung burial throughout the year. Further spread of the existing species by secondary releases and greater understanding of the reasons for differences in numbers between sites may be warranted.

ACKNOWLEDGMENTS

We thank the numerous beef and dairy producers who assisted in this survey. The comments of Mr A. Seberry and Ms B. Orchard were greatly appreciated during the preparation of this manuscript. Funding was received from the NSW River Care Program and the Hunter Catchment Management Trust.

REFERENCES

Allsopp, P.G. (1975). Dung beetles (Coleoptera: Scarabaeidae) collected in the Toowoomba District, south-east Queensland. *Aust. Entomol. Mag.* **2**: 47–49.

Allsopp, P.G. (1977). Further records of dung beetles (Coleoptera: Scarabaeidae) from the Toowoomba District. *Aust. Entomol. Mag.* **3**: 101–103.

Bornemissza, I. (1971). Biological adjustment of the population size of *Haematobia exigua* by the introduction of dung beetles in Australia. *Anzeiger fur Schadlingskunde und Pflanzenschutz* **44**: 9–10.

Bornemissza, G.F. and Williams, C.H. (1970). An effect of dung beetle activity on plant yield. *Pedobiologia* **10**: 1–7.

Bryan, R.P. (1973). The effects of dung beetle activity on the numbers of parasitic gastrointestinal helminth larvae recovered from pasture samples. *Aust. J. Agric. Res.* **24**: 161–168.

Doube, B.M. (1986). Biological control of the buffalo fly in Australia: the potential of the southern Africa dung fauna. *Miscellaneous Publications of the Entomological Society of America* No. 61: 16–34.

Doube, B.M. (1989). Role of dung in pasture productivity. Biological processes and the fertility of temperate and Mediterranean pastures, Melbourne. Hutchinson, K.J. (ed). p.104.

Doube, B.M. and Macqueen, A. (1991). Establishment of exotic dung beetles in Queensland: the role of habitat specificity. *Entomophaga* **36**: 353–360.

Edwards, P.B. and Aschenborn, H.H. (1987). Patterns of nesting and dung burial in *Onitis* dung beetles: implications for pasture productivity and fly control. *J. Appl. Ecol.* **24**: 837–851.

Fay, H.A.C., Macqueen, A., Doube, B.M. and Kerr, J.D. (1990). Impact of fauna on mortality and size of *Haematobia* spp. (Diptera: Muscidae) in natural dung pads in Australia and South Africa. *Bull. Entomol. Res.* **80**: 385–392.

Feehan, J., Hughes, R.D., Bryce, M.A. and Runko, S. (1985). Bush fly abundance and population events in relation to dung beetle catches on the south coast of New South Wales. *J. Aust. ent. Soc.* **24**: 37–43.

Flanagan, G.J. (1991). The distribution of the introduced dung beetle *Onitis alexis* Klug (Coleoptera: Scarabaeidae) in the Northern Territory. *Aust. Ent. Mag.* **18**: 101–102.

Gabriel, K. R. (1971). The bi-plot graphical display of matrices with application to principal component analysis. *Biometrika* **58**: 453–467.

Houston, W.W.K., Feehan, J.E. and Runko, S. (1982). Methods for harvesting large numbers of dung beetles (Coleoptera: Scarabaeidae). *J. Aust. ent. Soc.* **21**: 217–219.

Hughes, R.D., Tyndale-Biscoe, M. and Walker, J. (1978). Effects of introduced dung beetles *(Euoniticellus intermedius) (Coleoptera: Scarabaeidae)* on the breeding and abundance of the Australian bushfly, *Musca vetustissima* Walker (Diptera: Muscidae). *Bull. Entomol. Res.* **68**: 361–372.

McKinney, G.T. and Morley, F.H.W. (1975). The agronomic role of introduced dung beetles in grazing systems. *J. Appl. Ecol.* **3**: 831–837.

Ridsdill-Smith, T.J., Hayles, L. and Palmer, M.J. (1986). Competition between the bush fly and a dung beetle in dung of differing characteristics. *Entomol. Exp. Appl.* **41**: 83–90.

Roach, A. (1997). An assessment of manure breakdown and dung beetle activity during winter in the Williams River catchment. Project Report. The University of Newcastle and NSW Agriculture.

Seal, H. L. (1964). Multivariate Statistical Analysis for Biologists. Methuen and Co. Ltd., London.

Smith, T.J.R. (1981). Some effects of three species of dung beetles (Coleoptera: Scarabaeidae) in south-western Australia on the survival of the bush fly, *Musca vetustissima* Walker (Diptera:Muscidae), in dung pads. *Bull. Entomol. Res.* **71**: 425–433.

Turnbull, R.C. (1992). Dung beetle release in Illawarra. Illawarra Newsletter. **64**: 7–8.

Tyndale-Biscoe, Marina (1990). Common dung beetles in pastures of south-western Australia. CSIRO Australia, Division of Entomology 71 p.

Tyndale-Biscoe, M. (1996). Australian introduced dung beetles: Original releases and redistribution. Technical Report 62. CSIRO, Canberra.

This page left blank intentionally