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# Habitat use by grey-crowned babbler, *Pomatostomus temporalis*, in urban and peri-urban environments

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**Abstract.** Habitat loss in the urban environment leads to a high rate of local extinction of native fauna. In contrast, where key habitat structures, such as woody debris, shrubs and trees, are maintained, urban landscapes can retain many native species. To manage urban habitats successfully for urban bird communities, it is, therefore, necessary to understand the habitat requirements of the species using them. We have previously shown that the grey-crowned babbler, *Pomatostomus temporalis*, exhibits similar mean weight, sex ratio and group size in natural and altered habitat in and around Dubbo, New South Wales. In the present study, we detail the movements and habitat use of the groups that inhabit urban areas. We found that groups behaved similarly in urban and peri-urban areas, but showed small differences in the frequency of behaviours, based on the habitat feature that was available. The results suggested that, despite the decline of the grey-crowned babbler in the southern parts of its range, this species is able to survive in altered habitats, if nesting habitat and ground cover remain available and neighbouring groups persist nearby. Because other woodland bird species have shown similar responses to urban environments, managers of urban parkland should provide foraging substrates for a variety of woodland bird species, including vulnerable species, to ameliorate threatening processes and protect key habitat requirements.

**Additional keywords:** behavioural ecology, spatial ecology, urbanisation.

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## Introduction

Cities and towns tend to have bird assemblages different from those of the surrounding areas of more natural vegetation. Typically, the most urban parts of cities have a few relatively abundant, omnivorous bird species that can exploit nesting sites in buildings and food provided intentionally or incidentally by humans (Clergeau *et al.* 1998; Chamberlain *et al.* 2009). The suburbs that contain a higher vegetation cover of native flora have a wider range of species that exploit resources similar to those in their natural habitats (Clergeau *et al.* 1998). Within Australia, urban sites have avian assemblages dominated by exotic birds and medium-sized to large granivores, nectarivores or frugivores (Sewell and Catterall 1998; Ikin *et al.* 2014; Rayner *et al.* 2015). Reserves with native vegetation in and around the cities tend to have more small to medium-sized insectivores (Ikin *et al.* 2014) that tend to avoid urban areas (Rayner *et al.* 2015).

The grey-crowned babbler (*Pomatostomus temporalis*) is a medium-sized, ground-foraging insectivore inhabiting woodland in northern and eastern Australia. Its behaviour and ecology have been well studied in natural and semi-natural vegetation, where it lives in family groups in open woodland, with some tall shrubs, abundant leaf litter and grass (Robinson 1994; Simondson 2001; Stevens *et al.* 2015). Grey-crowned babblers breed co-operatively and roost together in dome-shaped nests at night, except while breeding when the primary female remains in a breeding nest. Each group has several roosting nests scattered throughout their home range (Gill and Dow 1984). The species is declining in south-eastern Australia (subspecies *temporalis*), vulnerable in New South Wales (NSW OEH 2012), endangered in Victoria (Davidson and Robinson 1992) and extinct in southern South Australia, and presumed extinct in the Australian Capital Territory (Higgins and Peter 2002), because of habitat loss and degradation (Olsen 2008). It mostly avoids towns and cities (www.birdata.com.au/maps.vm, accessed 12 October 2009), although it may occur in surrounding woodland or wooded farmland. Grey-crowned babblers are fairly common in and around the city of Dubbo, in central western New South Wales (Lambert *et al.* 2013). Dubbo may be located at a transition point, with heavy declines in the original winter-wheat farmlands to the south (Higgins and Peter 2002). Groups in Dubbo are of a similar size and composition by age and sex to those in more natural habitats (Lambert *et al.* 2013). In the present paper, we compare the foraging ecology, home-range size, nest sites and interspecific interactions of grey-crowned babblers across an urban to natural gradient in Dubbo and with other studies in natural habitat. We examine the hypothesis that the species uses semi-natural resources that are available in the city, showing behavioural plasticity to the urban environment.

## Materials and methods

Ten groups of grey-crowned babbler, from ~45 groups in the area (Lambert *et al.* 2013), were studied from May to August 2009, in and around the city of Dubbo in central New South Wales, Australia (32°15′S, 148°44′E). Babbler groups were found in native vegetation in Beni State Conservation Area, in remnant vegetation on private, mostly cleared land outside the city (peri-urban), in an urban housing estate, and in parks, gardens and sporting grounds in the city (urban) (Lambert *et al.* 2013). The local native vegetation is ironbark–cypress woodland dominated by *Eucalyptus nubila*, *E. crebra* and *Callitris glaucophylla*, on sandy infertile soil with a dense leaf litter and scattered small herbs, forbs and grasses. All urban sites contained small patches of natural or replanted vegetation, parkland, private gardens, roads, houses and other buildings. Disturbances included traffic, grazing cattle and sheep, motorcycle riding and houses outside the city, and traffic, pedestrians, cyclists, mowing, domestic animals and recreational activities within the city. Continuous vegetation is defined as large remnants of ironbark–cypress woodland >250 m wide. The peri-urban habitats had clumped vegetation where trees grew in patches rather than as linear strips in urban habitats.

In New South Wales, grey-crowned babblers may start breeding as early as July and fledge their last broods in March (Blackmore and Heinsohn 2007). Our study was conducted in the non-breeding season, when home ranges are larger (Counsilman 1979; King 1980; Dow and King 1984; Lambert *et al.* 2013). Groups varied from 3 to 11, all groups had an adult pair and subadult birds that assist rearing young. Rainfall and responses to vegetation have been discussed in our previous study (Lambert *et al.* 2013).

### *Banding*

From the 10 target groups of babblers, we banded 61 of 66 individuals, with six groups completely banded during May 2009. We used mist nets and playback of territorial calls to attract and catch the birds. Each bird received a stainless steel band from the Australian Bird and Bat Banding Scheme, plus a unique combination of coloured plastic bands.

### *Daily behaviour and movement*

Scan-sampling of individuals within the whole group every 2 min was used to determine the behaviour of grey-crowned babblers. Behaviour was classified as described by King (1980), as follows: allopreening, autopreening, inactive perching, dirt-bathing, foraging, nesting and mating, flight, branch hopping, intra- and inter-specific interactions, and calling in unison and individually. Each group was observed for at least 25 min, to a maximum of 100 min, three times in both morning and afternoon (0700 hours to 1000 hours, 1500 hours to 1730 hours), on different days, with a maximum of 600 min per group (Appendix 1). Observation sessions began when the group was foraging and the birds appeared indifferent to the observer. Groups were randomly sampled between June and August 2009. Subsequent observation sessions on groups were ≥5 days apart, alternating between morning and afternoon

After locating the group, the observer recorded (1) the group's initial position, and again every 10 min during the observation period; a Tom Tom One (3rd edition; Tom Tom, Amsterdam, The Netherlands) GPS was used, and contained a SiRF Star III GSD 3TW$^{TM}$ Satellite signal processor for global positioning system (GPS) with an accuracy of <2.5 m (map datum: WGS84, data projection: UTM); (2) the behaviour of each visible bird every two min, particularly their feeding positions, movement and group sociality (as described by King 1980); and (3) any interspecific attacks, species involved, outcome and duration within the session (at each 2 min interval) were recorded. We calculated the total number of times that each behaviour was shown at all per observation period. We also calculated the percentage of time foraging, interacting and moving. The frequency of each behaviour was compared among groups using an ANOVA.

The percentage of bare ground, vegetation and leaf litter was estimated (June 2009) in 30 1 m × 1 m quadrats at the three sites where each group foraged most (determined during observations). Foraging was separated by substrate, namely, ground, branches, trunk, log and other. The second-most visited area in the South Dubbo Oval home range was inaccessible and was substituted with the next most visited area.

### *Interspecific interactions*

The species attacking or being attacked by other babblers was noted, as was the length of time of any interaction. Interaction times were summed for each group and converted to a percentage of total time.

### *Nest sites*

Because the present study was conducted in the non-breeding season, only roosting nests were examined. The three most intact nests, resembling a dome-shape, were measured in each home range. For each nest, the tree species, tree and nest heights were recorded. We used a DWL-80G DigiPas$^{TM}$ (Irvine, CA, USA) clinometer and a 50-m tape measure to determine heights.

### *Home ranges*

The distance travelled by a group during each observation period was calculated from the GPS locations of the starting and finishing points, and for the start and finish of every 10 min of observation. Distances were calculated using the ruler path tool in Google$^{TM}$ Earth 5 (Mountain View, CA, USA). The total distance travelled in each observation session was calculated by summing the distances travelled every 10 min. A general linear model was used to test whether there was any effect of distance travelled over time by group size and site, to determine whether groups travelled further if they were larger or if the available habitat played a role. Only sessions that were 100 min in length were compared.

Throughout the observation time period, the GPS location of each group every 10 min was recorded subsequently during each 100-min session, so the locations were not statistically independent. The minimum convex polygon (MCP) method is the only conventional method that allows the use of locations recorded successively from the same group. Other methods have been claimed as having increased accuracy, such as those used by Portelli (2005) and Ostro *et al.* (1999); however, these methods have been shown to produce similar home-range

**Table 1. Comparison of the percentage of time spent among different foraging, social and movement behaviours of grey-crowned babblers. Bold text indicates the highest percentage of behaviour in that type**

| Major behaviour | Percentage time spent | Specific behaviour | Percentage time spent |
|---|---|---|---|
| Foraging | 70.1 ± 4.82 | Branch | 15.99 ± 8.40 |
| | | Trunk | 1.69 ± 1.67 |
| | | Logs | 1.38 ± 1.78 |
| | | **Ground** | **50.72 ± 9.76** |
| | | Other | 0.31 ± 0.34 |
| Movement | 13.1 ± 3.21 | Branch hopping | 2.24 ± 1.26 |
| | | Individual flight | 0.93 ± 0.38 |
| | | **Successional flight** | **9.07 ± 3.26** |
| | | Ground hopping | 0.87 ± 0.49 |
| Social | 16.7 ± 5.47 | Unison calling | 1.98 ± 1.19 |
| | | Individual calling | 1.64 ± 2.21 |
| | | Conspecific/interspecific interactions | 0.58 ± 0.49 |
| | | Dirt bathing | 0.11 ± 0.33 |
| | | Roost nest building | 1.81 ± 2.19 |
| | | Inactive perching | 4.03 ± 2.46 |
| | | **Autopreening** | **5.94 ± 2.19** |
| | | Allopreening | 0.64 ± 0.80 |

results for each group (Portelli 2005). Thus, the MCP method was used to determine each home range.

The MCPs were created using ArcGIS (Esri, Redlands, CA, USA) by (1) converting all GPS locations into decimal degrees, (2) putting the data into the XY table form by using ArcCatalogue, (3) setting the coordinate system to WGS 1984, (4) converting the data to easting and northing in the UTM Zone 55s and (5) adding them to ArcMap using Hawth's Tools (downloaded from www.spatialecology.com/htools/download.php, accessed 12 October 2009). All home ranges were aligned with Google Earth images to identify important features, such as patches or strips of vegetation, within each home range. Each home-range polygon was made hollow within ArcGIS and then exported to Paint.NET, where the background was made transparent. The main corners of the polygon were recorded as GPS locations and placed in Google Earth as reference points for the polygon placement. The polygons were then imported and aligned with the reference points.

## Results

### *Percentage of time spent for each behaviour*

Groups spent ~70% of their time foraging, 17% in social behaviour and 13% moving. There were no significant differences among groups in these proportions (Table 1; $n = 8$, $F_{2,7} = 0.05$, $P > 0.05$).

Foraging on the ground, namely, in leaf litter, vegetation and on the soil, was the commonest foraging behaviour, with branches being the second most preferred substrate. This was true in all sites, except one urban site, in which babblers foraged slightly more on branches. Birds in all groups foraged on tree trunks, and all but three groups (urban) foraged on logs. Other sites, such as playground equipment, were used infrequently (Table 1, Fig. 1). The ground in babbler home ranges had vegetation (mean = 43.6% ± 7.5 s.d.), leaf litter (mean = 37.1% ± 8.3 s.d.) and bare ground (mean = 19.3% ± 6.9 s.d.).

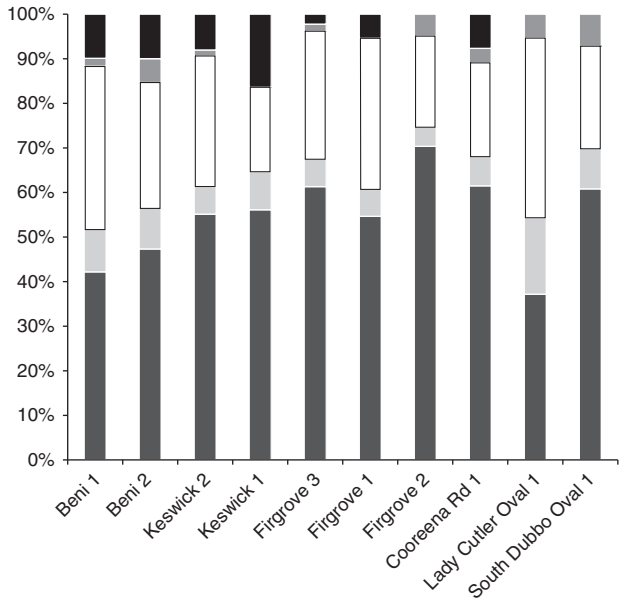


**Fig. 1.** Foraging preferences of grey-crowned babbler groups. Soil and leaf litter (dark grey); tree trunk (light grey); branches (white); other, e.g. playground (middle grey); and logs (black).

Most movements involved groups flying together, with individuals flying one after the other, rather than birds flying off individually. Babblers spent very little time hopping on the ground or on branches. Instead, babblers on the ground spent most of their time foraging (Table 1).

Preening was the most frequent social behaviour, mostly birds preening themselves, occasionally other birds. Inactive perching accounted only for ~4% of time, and a variety of other behaviours, including building and attending roost nests, involved less time (Table 1).

**Table 2. Interspecies aggression towards grey-crowned babblers in urban areas**

| Attacking bird | Number of groups attacked | Total time (s) |
|---|---|---|
| Honeyeaters | | |
| Noisy miner | 7 | 538 |
| Blue-faced honeyeater | 2 | 59 |
| Red wattlebird | 1 | 96 |
| Artamids | | |
| Grey butcherbird | 1 | 40 |
| Australian magpie | 7 | 273 |
| Monarchids | | |
| Magpie lark | 1 | 2 |

### *Interspecific and intraspecific interactions*

Grey-crowned babblers spent 0.58% + 0.49 (mean ± s.e.) of their time interacting with other species. Larger groups spent more time than smaller groups in interacting with other species ($F_{1,7} = 6.96$, $P < 0.05$). Most groups were attacked by one or two aggressive species, although groups at Cooreena Road and South Dubbo Oval, were attacked by four species. The main aggressors of grey-crowned babblers were large honeyeaters or artamids, with one brief attack by a magpie lark (Table 2). Attackers were usually a single bird swooping on a group of foraging grey-crowned babblers. Babblers usually responded by forming defensive huddles. Attacks lasted from 2 to 30 s.

Babblers interacted with members of neighbouring groups in a variety of ways. They occasionally chased birds in other groups from assumed territorial borders or met at their common border and called and displayed to each other (0.59% ± 0.58 (mean ± s.d.) of time). At other times, babblers foraged with birds from other groups.

### *Nest sites*

One group, in Keswick Estate, had four roost nests, whereas the other seven groups in Dubbo had three. Fourteen roost nests were in *Callitris* spp., 10 in *Eucalyptus* spp. and one in an *Acacia*. Nest height did not differ significantly among tree species ($F_{2,10} = 0.79$, $P > 0.05$) or among groups ($F_{7,10} = 1.57$, $P > 0.05$). Nests were positioned at a mean height of 11.25 m ± 5.41 (mean ± s.d.; $n = 25$ pooled across tree species and habitats), representing 56% ± 11.86 (mean ± s.d.) of the height of the nest tree (range = 3.3–22.5 m).

### *Movements and home ranges*

The average area of home ranges was 18.34 ha, with a range of 9.43–65 ha. The group with the largest home range was at South Dubbo Oval near the city centre. However, home-range size was not related to distance from city centre ($r^2 = 0.12$, $n = 10$, $P = 0.328$) and neither was group size ($r^2 = 0.074$, $n = 10$, $P = 0.447$). Furthermore, group size had no effect on home range ($r^2 = 0.11$, $n = 10$, $P = 0.773$). The groups at Beni CA used the forest, and crossed a minor road to forage at the edge of cleared land (Figs S1 and S2, available as Supplementary material to this paper), which they crossed to small patches of trees and even foraged 10 m away from trees. All urban groups used small patches and linear strips of vegetation as well as scattered trees and sometimes crossed open areas up to 200 m between trees. The two groups in the city crossed treeless sports grounds, and the South Dubbo Oval group crossed 600 m of residential land to an isolated patch of trees.

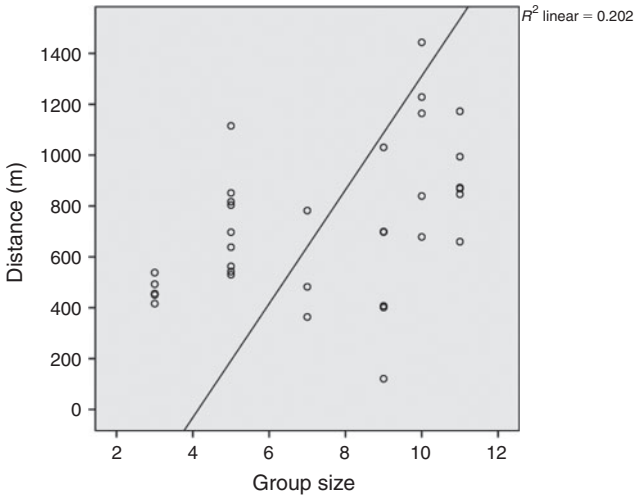


**Fig. 2.** The relationship between the total distance travelled (m) within 100 min and group size in the grey-crowned babbler.

Groups moved an average of 688.84 m in 100 min. Larger groups tended to move further within 100 min of observation (Fig. 2; $r^2 = 0.20$, $F_{5,27} = 3.89$, $P < 0.05$). However, urban groups did not move further than peri-urban groups ($F_{1,9} = 0.00$, $P > 0.05$), and urban groups were a size similar to that of peri-urban groups ($F_{1,9} = 0.00$, $P > 0.05$).

## Discussion

Grey-crowned babblers within Dubbo spent similar proportions of time foraging, moving and interacting socially, to those in surrounding rural and natural sites. In association with no difference in body mass between the groups in natural sites and those in urban areas (Lambert *et al.* 2013), this indicates that food is adequate in urban areas. Rainfall was sufficient for the two years preceding this study, as discussed by Lambert *et al.* (2013), and mowing and watering may have all contributed to food availability on lawns and within leaf litter in each home range.

Babblers in Dubbo occupied sites with proportions of ground cover (44%) and leaf litter (37%) similar to those in northern Victoria (45% ground cover, 46% leaf litter, Robinson *et al.* 2002). Our urban sites had less leaf litter but more ground cover. However, Stevens *et al.* (2015) found that grey-crowned babblers had home ranges with as much as 96% ground cover. Future research could sample arthropods in home ranges of grey-crowned babblers in urban and natural sites, to determine how much food is available and whether there are any differences in insect assemblages and abundance. These results could then be used in conjunction with preferences of foraging behaviour to guide management practices.

They mostly foraged on the ground, less often from tree branches and trunks, as also found by previous studies in more

**Table 3. Comparison of time spent foraging in urban habitat**

| Location | Substrate | Percentage of time | Reference |
|---|---|---|---|
| Dubbo, NSW | Ground | 52.6 | This study |
| | Tree trunks and branches | 15.6 | |
| Kakadu, NT | Ground | 31 | Brooker *et al.* 1990 |
| | Trunks and large branches | 27 | |
| Dyer's Lagoon, NT | Ground | 76.1 | Counsilman 1980 |
| | Tree branches | 7.4 | |
| Boningar, NT | Ground | 55.3 | Counsilman 1980 |
| | Tree branches | 13.6 | |

natural habitat (Table 3). Unlike in Dubbo, birds in larger groups in Boningar and Dyer's Lagoon spent more time foraging than did those in smaller groups, because the former depleted their food or spent more time in social behaviour (Counsilman 1977).

Grey-crowned babblers in Dubbo spent less than 1% of their time interacting with other bird species. They were mostly attacked by large honeyeaters and artamids, especially noisy miners and Australian magpies, which are common in urban areas and disturbed woodlands in eastern Australia because of their aggressive nature. Counsilman (1977) also found that noisy miners and Australian magpies were the main aggressors of grey-crowned babblers in Queensland and Stevens *et al.* (2015) stated that noisy miners frequently harassed grey-crowned babblers in Victoria. Most attacks occurred when babblers were feeding on the ground rather than near a nest. Counsilman (1977) also observed magpie larks pursuing foraging babblers on the ground. We consider that the interaction results showed that babblers may be resilient to interference from other species, because groups continued to forage and had body mass (Lambert *et al.* 2013) similar to that of all other studied groups.

Grey-crowned babblers in and around Dubbo built roost nests in native plants such as *Callitris*, eucalypts and acacias, as they do in natural habitats (Counsilman 1977). The Coreena Road group had the fewest trees in their home range (~30 trees); however, babblers were still observed roosting in them, suggesting that grey-crowned babbler groups may need at least this many trees to survive in an urban area. Therefore, unlike many ground-foraging insectivorous species in Australia (e.g. Major *et al.* 2001; Hodgson *et al.* 2006; Briggs *et al.* 2007), they may be able to survive in urban areas as long as some native trees are present; however, this needs further investigation.

The home ranges of grey-crowned babblers in and around Dubbo (18.3 ha) were of a size similar to that in two sites in Queensland (Table 4). One home range in central Dubbo, around a football oval, was much larger (65 ha) than all other home ranges (8.5–25.3 ha), partly because birds crossed a residential area to a patch of trees. However, the other babbler home range in central Dubbo was about average size (16.1 ha). Also, one site in rural Queensland had larger average home ranges (Table 4), with the largest being 94.5 ha. The group with the large home range had seven members, including four juveniles (Lambert *et al.* 2013), suggesting that it had adequate food to breed successfully.

All groups in Dubbo, including those in Beni State Forest, spent considerable time among scattered trees, often foraging in open ground up to 10 m from trees. They also frequently made use of grazed pastures and mown lawns and sports fields. However, because of the small sample size, we were unable to analyse the habitat use of each group separately over time, but we did observe small differences in foraging preferences. For example, all groups foraged on soil and leaf litter most, except for the Lady Cutler Oval one, which used branches most. This group was located on a sporting oval and was disturbed by people walking, driving cars and taking dogs. Constant mowing may also have reduced food availability, causing babblers to probe for insects on trees. They also may have used trees for protection from predators as their group had only three members (Lambert *et al.* 2013).

**Table 4. Comparison of home ranges among studies in continuous habitat**

| Location | Range (ha) | Mean | Reference |
|---|---|---|---|
| The Dell, Qld | 40–94.5 | 58.05 | Moffatt 1982 |
| Boningar, Qld | 1.7–42.9 | 11.15 | King 1980 |
| Flinders Peak, Qld | 5.3–52.7 | 22.24 | King 1980 |
| Dubbo, NSW | 8.5–65.0 | 18.34 | This study |

In conclusion, the grey-crowned babbler in Dubbo appears to be well able to cope with the urban environment. There was minimal difference in the species behaviour across the spectrum of urban to natural environments, or in comparison with semi-natural sites elsewhere in Australia. This agrees with the similar size and composition of these groups that we found across the urban to natural range (Lambert *et al.* 2013). The loss of key features, such as native roost trees, and trees that provide foraging substrate in Dubbo could have a negative impact on the local population of babblers. It is important that these trees are retained if the city is to sustain this threatened woodland bird. However, further examination of the number of trees required within a home range is required for future native-tree management within these areas.

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## Appendix 1. Details of observation sessions of grey-crowned babblers in each group

The date and time of each observation is displayed, with the duration (min) after the date. The total observation time is displayed in the last column, of the aim of 600 min

| Group | ~0700 hours to 1000 hours | ~1500 hours to 1730 hours | Total time (min) |
|---|---|---|---|
| Cooreena Rd 1 (CR1) | 10 June 2009 (100) | 22 June 2009 (100) | 448 |
| | 22 July 2009 (80) | 9 July 2009 (40) | |
| | 20 Aug. 2009 (78) | 3 Aug. 2009 (50) | |
| South Dubbo Oval (SH1) | 4 July 2009 (80) | 15 June 2009 (64) | 488 |
| | 29 July 2009 (100) | 13 July 2009 (44) | |
| | 25 Aug. 2009 (100) | 17 Aug. 2009 (100) | |
| Lady Cutler Oval 1 (LC1) | 13 June 2009 (50) | 17 June 2009 (100) | 550 |
| | 17 July 2009 (100) | 30 July 2009 (100) | |
| | 14 Aug. 2009 (100) | 24 Aug. 2009 (100) | |
| Keswick 1 (K1) | 21 June 2009 (100) | 9 June 2009 (100) | 600 |
| | 7 July 2009 (100) | 23 July 2009 (100) | |
| | 5 Aug. 2009 (100) | 31 Aug. 2009 (100) | |
| Keswick 2 (K2) | 23 June 2009 (100) | 20 June 2009 (100) | 600 |
| | 26 July 2009 (100) | 8 July 2009 (100) | |
| | 18 Sep. 2009 (100) | 7 Sept. 2009 (100) | |
| Firgrove 1 (F1) | 24 June 2009 (100) | 12 June 2009 (80) | 580 |
| | 21 July 2009 (100) | 7 July 2009 (100) | |
| | 17 Aug. 2009 (100) | 26 Aug. 2009 (100) | |
| Firgrove 2 (F2) | 30 June 2009 (60) | 16 June 2009 (60) | 406 |
| | 30 July 2009 (32) | 16 July 2009 (100) | |
| | 24 Aug. 2009 (54) | 14 Aug. 2009 (100) | |
| Firgrove 3 (F3) | 8 July 2009 (80) | 11 June 2009 (88) | 560 |
| | 7 Aug. 2009 (100) | 23 June 2009 (100) | |
| | 25 Aug. 2009 (92) | 18 Aug. 2009 (100) | |