RESPONSE OF TRAPDOOR SPIDERS TO FIRE IN THE STIRLING RANGE

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Report on a post-fire monitoring study:

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1. OBJECTIVES

To assess the effect of the April 1991 fire on:

(1) Relic species of trapdoor spiders (Mygalomorphae)
(2) Other species of trapdoor spiders, araneomorph spiders and selected invertebrates if opportune

and predict what the long term prognosis might be for the above, particularly the relict trapdoor spiders.

Barbara York Main
18 December 1992

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EXECUTIVE SUMMARY

Background and objectives

1. Following the fire in the eastern block of the Stirling Range in April 1991 a study was undertaken (late November 1991-late January 1992) to :
   assess the effect of the fire on selected species of trapdoor spiders namely the relic species *Neohomogona stirlingi* Main, an undescribed species of *Moggridgea* and a new endemic species of *Eucyrtops* and where possible other spiders .

2. Previous studies on the effect of fire on spiders generally, both overseas and in Australia are briefly reviewed. No previous studies have considered trapdoor spiders (mygalomorphs) i.e. long lived, sedentary ground dwelling spiders with limited dispersal range of juveniles.

3. The taxonomic composition of mygalomorph spiders in the Stirling Range is summarised and the most biogeographically significant species stated to be:

   (a) *Moggridgea sp.* (family Migidae). The genus is known elsewhere in Australia from the tingle forest in the southwest and Kangaroo Island S. A. A pre-Jurassic Gondwanan relic in Australia, it occurs widely in southern Africa.

   (b) *Neohomogona stirlingi* . Elsewhere the genus occurs in the Porongurup Range; the genus is closely allied to *Homogona* of northeastern Australian rainforests (N. S. W. and Qld.) and the Grampian Mountains and Mt Beauty in Victoria. A pre-Cretaceous relic with eastern Australian rainforests affinity.

   (c) A newly discovered species of *Stanwellia* (i.e. found during this study) and known to date only from the Cascades. Other species known elsewhere in W. A. only from West Cape Howe and a few very wet sites in the southwest. A relic Gondwanan genus (southern Australia, Tasmania and New Zealand).

   (d) An undescribed species of *Eucyrtops* (a southwest Australian genus). The species is endemic to the Bluff Knoll massif.

4. All these species are long-lived (i.e. take several to many years to mature), and dispersal of juveniles is restricted to the boundaries of the parent populations.

5. The effect of the fire on certain non-mygalomorph spiders (Araneomorphae) was also investigated e.g. the social crab spiders *Diaea socialis* .

Methods

Populations were censused (by measuring door diameters (*Moggridgea* & *Eucyrtops*) or palisade openings (*Neohomogona*) of viable nests) in demarcated plots in burnt sites (Bluff Knoll massif) and unburnt sites (MtToolbrunup, *Moggridgea* only). *Neohomogona* occurs more widely i.e. in less restricted habitats in the ranges than *Moggridgea* . However, during this study *Neohomogona* spiders were not located in dense enough aggregations on Mt Toolbrunup itself for statistical analysis even though it is known (from 1953 observations) that aggregations did/do occur at least on the coll between Mt Toolbrunup and Mt Hassell. Steel "dropper" pegs have been left in situ at the census areas for further monitoring if occasion arises.

Results indicated that:

(i) Observations showed that the immediate effects on the habitats were loss of canopy cover (at both tree and shrub level); destruction of soil cover (moss and litter); erosion of top soil of nest sites and instability of banks and slopes (slippage of stones, rocks and soil pockets); some contamination of creek water with ash and soil.

(ii) Effects on the spider populations were as follows:

(a) Moggridgea

Populations were adversely affected by the fire. There was a reduction of early instar spiders (e.g. with door diameter of less than 4mm). Also an overall mortality was indicated in that the mean number of nests per square M in the burnt area (22 +- 5.75) was significantly less than in the unburnt area (109 +- 21.38). Paradoxically the most favourable habitats suffered the most severely. This is because the wettest places, in the event of the intense fire were in fact burnt more badly and the soil mineralised or "ceramicised" with destruction of nests and spiders, including large ones. Thus in order to make statistical analyses, the less than optimal sites were generally sampled.

(b) Neohomogona

There was some variation in relative proportions of very small juvenile, moderate sized and adult nests and the total population density in the *Neohomogona* populations sampled (all burnt sites). Not all sites had a low proportion of small juvenile nests. These differences are interpreted in relation to the quality of the microhabitats. Optimal habitats are sites with deep sandy/loam soil (facilitating deeper burrows) and/or south facing, topographically shaded sites which have a high summer fog incidence.

Less favourable habitats include rocky sites with shallower soil, less canopy, more exposure and possibly less fog incidence.

Optimal habitat sites favoured higher initial population density, and also showed a relatively higher survival of both small juvenile spiders and older, larger individuals following the fire than did less favourable sites.

(c) Stanwellia

In that this genus had not previously been observed (in the Stirling Range) and nests have been seen only at one sheltered creek site, it is apparent that the species is extrememy rare. The few nests observed were in pockets protected from the fire in shallow soil in crevices beneath flat slabs of overhanging rock. If, as would be expected from the known occurrences of the genus elsewhere, the spiders occurred more abundantly in tubes in damp soil beneath undergrowth along the Cascades creek it is clear that the population would have been almost totally destroyed by the fire.

(d) Eucyrtops

The undescribed species of *Eucyrtops* (a primitive southern W. A. genus) from Bluff Knoll showed an unbalanced demographic population structure after the fire e.g. with less than would be expected juvenile instar nests. Observations indicated that the "best" habitats were the most severely affected. Like the most favourable sites of *Moggridgea* the soil was "ceramicised", and nests (doors) were baked or charred (as they contain a large proportion of silk) and spiders killed.

(e) Other spiders e.g. social thomisid *Diaea socialis*

Nests of the gum-leaf binding social spider *Diaea socialis* observed at the Cascades prior to the fire were destroyed, along with the canopy by the fire.

Management and Recommendations

Preamble

Moggridgea and *Neohomogona* are both Gondwanan relics of a biological scenario prevalent prior to the advent of fire as a natural element of the Australian biota. The incursion of fire associated with the development of a sclerophyllous vegetation would have initiated a marginalisation of habitats and partial fragmentation of populations.

With increased frequency, intensity and wider extent of fire due to human interaction the favourable habitats for these spiders have become both diminished and further fragmented. Thus, in turn this has further fragmented and isolated sub-populations of the species. Nevertheless, many mygalomorphs are "predestined" by nature of their aggregative life-style to persist as both small populations and in constricted habitats. [Perhaps a vertebrate analogue is the short necked tortoise].

From a *management* aspect the challenge is both philosophical and practical:

> Is it worth trying to preserve (? conserve) a population of an invertebrate - a pre-Jurassic biogeographic relic - in the wild?

If the answer is "yes", then how can this be done?

Recommendations

Conservation of ***Moggridgea***

(A) General

(i) Any prescribed burning should avoid (or be light burns only) -

- the deep shaded gullies on Bluff Knoll (e.g. Cascades and creeks crossing the Cascades walking path), and
- creeks of the southern faces of the Bluff Knoll, Moongoongoonderup, Isongorup, The Arrows (e.g Mirlpunda)

- the deep south east gully running from Mt Toolbrunup (running from above and towards the car park area, i.e. the walking path runs alongside this gully)

(2) If burning is to be undertaken in above areas

- avoid burning or scorching the tree canopy and so prevent undue leaf loss and thinning of the canopy and

- avoid scorching of creek banks which harbour spider burrows

(3) A survey should be made to locate as far as possible all sites where *Moggridgea* (the small relic Gondwanan trapdoor spider) occurs. Sites should be marked (with steel "droppers") so that at least some can be protected in the event of controlled burning.

(B) Specific

(1) As The Cascades becomes revegetated the banks (particularly the north banks which are naturally shaded) should be protected from visitor misuse e.g. sliding and that if access to the stream is to continue then steps be constructed to discourage indiscriminate scrambling over the bank.

(2) If control burning is to continue in the future then efforts should be made to exclude burning the north banks of The Cascades and other creeks along the Cascades walking trail. Special protection of *Moggridgea* populations could be ensured by "wrapping" small (populated) areas with wet hessian sheeting.

Neohomogona

If control fires are to be used as part of management procedures then they should be of long periodicity preferably not less than 20 and in selected sites, 40 year intervals - woodlands along Cascades walking path, creeks on south east aspect Bluff Knoll massif, south base of Bluff Knoll massif. The Toolbrunup Peak should be protected from fire.

Eucyrtops

Fire protection and minimum "cutting" of upslope banks of Bluff Knoll walking path on lower region i.e. between junction of Cascades walking path and creek crossing.

At the Cascades as for *Moggridgea.* Where north slopes are revegetating i.e. away from the creek avoid burning for 20 (?) years to allow re-establishment of population in sheltered areas such as below jutting rocks, logs.

Social crab spiders - *Diaea socialis*

It is doubtful whether any spiders survived the fire in the Cascades area, however on Mt Toolbrunup protection from fire in the south east gully (up which the walking path is directed) should ensure persistence of some spiders in this subpopulation.

If further nests are found *anywhere in the Range* these should be recorded and the tree canopy protected from fire.

CONTENTS

Response of trapdoor spiders to fire in the Stirling Range

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Introduction

Fire has long been recognised as a natural phenomenon in the southwest Australian environment and the adaptations to fire of heath and eucalypt vegetation associations, remarked upon by Gardner (1957), have since been corroborated by many workers. The corollary that the fauna is similarly fire adapted or at least resilient to fire has thus been assumed and to some extent demonstrated to be so, particularly with vertebrates (Christensen 1980). While some work on selected invertebrates appears to indicate that infrequent, moderately hot fires do not permanently jeopardise persistence of populations (Majer and Abbott 1989) few studies have taken cognisance of the problems faced by relic taxa which may be anachronistic survivors of a biological scenario which preceded the advent of fire in the environment.

It is with just such relic spider taxa that this study is concerned. Nevertheless, the study needs to be viewed within the broader context of earlier work on the effect of fire on spiders generally and the ecological role of arthropods.

Studies of the effects of fire on arthropods have not generally addressed the interrelationships with other fauna or emphasised the dependance of higher fauna on the soil/litter fauna (including spiders). Thus Springett's study (Springett 1979) is of interest. In this study she demonstrated that there was a reduction in numbers of microarthropods (including spiders), in the proportion of juveniles and the representation of fungal feeders, a year after a hot fire in jarrah forest. An important aspect appeared to be the loss of fungi on which many microarthropods depend and which in turn provide prey for small predatory arthropods. This illustrates that the base of the food web of an established community is affected by fire.

Recovery time of the *basic* interactions is still generally unknown. Nevertheless, biologists are aware of the role of fungi and saproxylic organisms (those living on dead or decaying wood) and the need to isolate and safeguard some "old" growth areas from fire in order to preserve such elements of the biota. This contention is borne out by the Recommendation of the Council of Europe Committee of Ministers (Anonymous 1988) and a modified version appropriate for the Australian environment submitted by the Conservation Committee of the Australian Entomological Society to the Australia and New Zealand Environment and Conservation Council (ANZECC).

Studies on response of spiders to fire

There have been few studies on the response of spiders to fire and none dealing specifically with trapdoor spiders (Mygalomorphae). Most studies have been pursued within the context of management procedures for maintenance and restoration of habitat. Several studies in North America and England have been conducted , sometimes fortuitously, in prairie and heath habitats. Weaver (1986) in a study of effects of fire on spiders in a prairie in Missouri, U. S. A., showed that species diversity was higher in two and five year post-fire plots than in one year post-fire and control plots. Riechert and Reeder (1972) found that spider species composition over time was not adversely affected with periodic burning of prairie in southwestern Wisconsin U S A. However the retention of such species composition was dependent on recolonisation from unburnt patches in well established prairie communities. In accidentally burnt heathland in Dorset, England, Merret (1976) found a sequential suite of spider species reestablished in relation to recovery of the vegetation. In a study of the diversity of ground spiders on Yorkshire moors, Usher and Smart (1988) noted that species richness was higher in areas with a vegetation mosaic of different ages (in relation to burning regimes) than in areas of comparable size but with vegetation of uniform age. None of these studies related to forest or woodland sites.

Southwest Australian studies

In southwestern Australia Springett (1976) compared the mesofauna of soil and litter habitats in burnt and unburnt forest sites of jarrah (*Eucalyptus marginata*) and karri (*E. diversicolor*). The numbers of spiders in unburnt sites was twice and three times that of burnt sites in jarrah and karri respectively. By contrast Abbott (1984) demonstrated no differences in the numbers of spiders in soil cores and pitfall samples in burnt and unburnt sites during a study comparing numbers of representatives of selected taxa of "larger" invertebrates of the soil and litter. However, no detailed consideration was given to the life history stages of the spiders, nor of the species composition. In that some cursorial spiders and wandering males may readily migrate rapidly into recently burnt sites (depending on the time of year in relation to the spiders phenological reproductive activity), high numbers after a fire may reflect this movement rather than be indicative of site-specific population (and individual species) recovery. In a study of spider species richness and recolonisation in relation to managed Banksia/jarrah woodland in Kings Park, Perth, it was found that certain moisture-loving soil/litter spiders occurred only in long unburnt litter (about 16 years) or under fire resistant shrubs e.g. *Jacksonia* (Barendse et al, 1981). Main (1987) indicated that certain Gondwanan relic spider species in coastal heath in Torndirrup National Park, are vulnerable to fire and reestablish slowly from unburnt patches. For example, 17 year post-burn sites contained more relic species and in higher numbers than did two and four year post-burn sites.

Trapdoor spiders (Mygalomorphae)

In all these studies the spiders discussed have been araneomorphs (apart from a few specimens amongst the Springett and Abbott samples) which generally have a greater capacity for aerial dispersal and more rapid recolonisation potential than do most species of Mygalomorphae. Thus, such studies may not be a good guide to the possible effects of fire on trapdoor spider populations.

In a recent study (Main 1991a, 1992) of the response of selected species of trapdoor spiders to fire in a Wheatbelt habitat, the generalisation emerged that:

(a) adults of door-building species (and probably many open-holed species) which are long lived, have a long maturation period, and with ambulatory dispersal, may survive even a very hot fire but that the population is thereafter at risk and that recovery is slow and

(b) web weaving/burrowing species with capacity to shift nest site, which have a rapid maturation period and have wind-borne dispersal, although killed by fire are able to recolonise within a year post fire *from* *adjacent unburnt sites* .

Given that most species of mygalomorphs in Western Australia belong to the first group, i.e. are burrowers but not web-weavers and have ambulatory (restricted) dispersal capacity, the majority of species are likely to be highly vulnerable, in a population and persistence sense, to fire.

Biology of trapdoor spiders (Mygalomorphae) in the Stirling Ranges with particular reference to relic species

Most trapdoor spiders are generally long lived, sedentary, terrestrial burrowers and have a low dispersal capacity (Main 1976, 1985b) and thus generally conform to the first group discussed above. They fill a major predatory role in many invertebrate food chains. These characteristics mean that their responses to sudden or catastrophic events, including fire, and habitat changes can give a good indication of recovery of invertebrate community structure following such events and modifications. On the other hand individual species may respond differently due to specific microhabitat requirements.

Thirteen or more species of trapdoor spiders occur in the Stirling Range. At least five species are endemic and of these, two are of particular zoogeographic interest, as well as ecological significance, because of their relictual status. These are an undescribed species of *Moggridgea* Cambridge (family Migidae) (Fig. 5) and *Neohomogona stirlingi* Main (family Idiopidae) (Figs 6, 7).

The African genus *Moggridgea* is known elsewhere in Australia only from Kangaroo Island South Australia and the tingle forest near Walpole. Belonging to the Gondwanan family Migidae it has been separated from Africa since the Jurassic (Main 1991b). The southwest Australian occurrence of the genus suggests that it may retain an affinity for a habitat scenario pre-dating the occurrence of fire in the landscape similar to that for other Gondwanan spider relics as postulated by Main (1987).

Spiders of the genus *Moggridgea* are small (less than a centimetre). The spiders occur in very damp habitats and *M. tingle* Main makes short cocoon-like tubes, closed by a circular door, on the bark of trees (tingle) or on the ground in the Walpole/Nornalup region. An undescribed species (Fig. 5) was first found in the Stirling Ranges in 1990 by one of us (BYM). Spiders of this species construct short tubes which may be stuck to the ground surface or the spiders dig shallow burrows with silk-bound soil trapdoors in moist, permanently shaded banks of creeks. In pockets of particularly favourable microhabitats specimens occur in dense aggregations. Prior to this study populations had been located only on two aspects of Bluff Knoll (the Bluff Knoll walking path and The Cascades).

Evidence from the Walpole area indicates that *Moggridgea* is vulnerable to fire. Sites on the Deep River and Mt Clare, have shown many nests destroyed by controlled fires with no subsequent recovery; elsewhere, e.g. in The Valley of the Giants it has been noticed that nests occur only on the bark of long unburnt tingle trees (Main 1991b and BYM personal observations).

The genus *Neohomogona* Main is endemic to the Porongurup and Stirling Ranges with a distinct species in each of the ranges (Main 1985a). The genus is closely related to *Homogona* Rainbow, a genus characteristic of rainforest and montane sites in eastern Australia, particularly Queensland, northeastern N S W and the Grampian Mountains and some sites north of Melbourne in Victoria. [Although Raven (1985) considered *Neohomogona* and *Homogona* both as synonyms of *Cataxia* Rainbow, *Neohomogona* is here (following Main 1985a, b) considerered a valid genus]. *Neohomogona* has been isolated in W A probably since the Cretaceous. The populations in the two mountain blocks of the Stirling and Porongurup Ranges would have been separated by the early Tertiary marine transgression (about 40-50 mya) and now represent two endemic species. Behaviourally the spiders retain the characteristics of the eastern montane *Homogona* species which require shaded, moist situations. *Neohomogona* species are confined to higher elevations in the mountains, particularly above the cloud line or to southern slopes or shaded sites which receive summer drizzle which helps to maintain a damp, "non seasonal" microhabitat. *Neohomogona stirlingi* (Figs 6, 7) digs relatively shallow burrows (up to about 20cm deep) with an open entrance surrounded by a collar or palisade of leaves and litter debris (Fig. 8). The species occurs abundantly on the Toolbrunup/Mt Hassell and Bluff Knoll mountain complexes (Main 1985a and personal observations). There is some evidence from earlier observations that individual spiders of *Neohomogona* can survive at least moderate fire as an aggregation of spiders on the south base of Bluff Knoll were noted to have reconstructed the palisade-like entrances of nests following a fire in 1957 (BYM and A R Main personal observations).

In the absence of any quantitative records it has not previously been possible to assess the effects of fire on populations of either of the above species. The large scale fire of April 1991 which spread over almost the whole of the eastern block of the Stirling Ranges, leaving only a few isolated unburnt refugia, suggested that the then only known populations of *Moggridgea* might have been destroyed and that *Neohomogona stirlingi* may have suffered a severe setback.

The present study therefore proposed to investigate the response of both *Neohomogona stirling* and the *Moggridgea* species to the fire, primarily in the short term but also to provide base data for future monitoring of populations. It was hoped also that deliberate search would reveal additional occurrences, particularly of the rare and behaviourally specialised *Moggridgea* . Some investigations were made also on a population of an endemic, undescribed species of the idiopid trapdoor spider genus *Eucyrtops* Pocock, which genus is elsewhere widespread in southwestern Australia. The burrows of the species discussed here extend up to about 20 cm and are closed by a thick, plug-like soil door.

In addition some observations were made on selected araneomorph species e.g. the social crab spider *Diaea socialis* Main.

Study sites and Methods

Study sites

Two main study areas were selected: (a) Burnt sites (i.e. burnt in the April 1991 fire) comprising several sites on the southwestern approaches (and one site on the south base) of the Bluff Knoll massif (*Neohomogona stirlingi*, *Moggridgea* and *Eucyrtops*) and (b) An unburnt site on the south east slope of Mount Toolbrunup where a recently found population of *Moggridgea* provided a "control". Because of the rocky terrain away from the creek banks, suitable sites for *Neohomogona* aggregations comparable to those occurring on the Bluff Knoll sites were not found. However it is known that at least some such sites of small area do occur on the MtToolbrunup/Mt Hassell peaks as the original location noted by one of us (BYM) was in a depression on the coll on the south side of Mt Hassell (Main 1985a). It was not expedient to relocate this site during the present study.

(a) *Bluff Knoll (burnt sites)*

The areas selected encompassed : a bank along the lower part of the Bluff Knoll walking trail (*Eucyrtops sp. site*); several sites along the walking trail to The Cascades (*Moggridgea Site 1*, and *Neohomogona stirlingi Sites 1* and *2*); The Cascades locality (*Moggridgea Site 2*) at the end of the walking trail; and a location on the south base of Bluff Knoll (*N. stirlingi Site 3*). *Eucyrtops* nests were also present at both the *Moggridgea* sites.

This whole area, and most of the eastern block of the Stirling Ranges, suffered a severe burn in April 1991 as the result of wild fire escaping from a prescribed burn (see Fig. 9). The most recent previous fire was in February 1972. Prior to that there was a severe fire on at least the southern slopes and base of Bluff Knoll in 1956/1957.

The predominant vegetation of all these sites is a mixed forest of jarrah (*Eucalyptus marginata* Donn ex Smith), red gum (*Eucalyptus calophylla* R. Br. ex Lindley) and wandoo (*E. wandoo* Blakely) with, until burnt, a moderately closed canopy which was completely destroyed by the fire (see Fig. 6). There is an open understory of *Banksia* , *Acacia,* black boy (*Xanthorhoea*), grass trees (*Kingia*), occasional *Allocasuarina decussata* (Benth.) and herbaceous shrubs. The whole of the canopy and understory was destroyed by the fire and 7-10 months later (post winter), there was no canopy restoration in spite of regenerating vegetation (Fig. 10).

Moggridgea nests were also located at the following other (burnt) sites (but in very low numbers, in some instances only one viable nest): several banks of a south flowing creek from the base of Moongoongoonderup (near *Neohomogona Site* 3) and Mirlpunda Creek (south of The Three Arrows) (see Fig. 15). *Eucyrtops* nests also occurred amongst the *Moggridgea* nests at the Moongoongoonderup locations.

Three different types of microhabitat were identified. Each of the three study species was associated with one particular type of microhabitat respectively as described below.

Eucyrtops sp. Site

Location and description of study site

The site is a south facing bank on the up-slope side of the Bluff Knoll walking path beyond the junction with the Cascades walking trail and between the eleventh and twelfth treads of the first group of steps. The dominant trees are wandoo with broken canopoy as a result of the burn. Crumbly clay soil derived from weathered phyllites is interspersed with small boulders and rock slabs. Some post-fire regeneration of ground cover plants was apparent at the time of recording, but the soil was generally bare. Most spider burrows were sited below the overhang of rocks and down slope against tree butts. Post-fire erosion of the bank was apparent in exposed rocks, loose soil and slippage which had resulted in formation of holes up to half a metre in diameter. This site had been identified in July 1990 (before the fire) as supporting a prolific population of *Eucyrtops* (BYM records).

Moggridgea sites

Location and description of sites

Site 1. The second creek crossing (south facing bank) along the walking trail.

This creek is not in such a deeply incised gorge as that of The Cascades but nevertheless has some jutting rocks suitable for black fly (Simulidae) larvae which provide prey for *Moggridgea* . *Moggridgea* nests were situated in pockets of loamy clay soil in a band of the south facing bank about one and a half metres wide extending from just above the water level. Although well covered with moss and liverworts and shaded by low shrubs prior to the fire, no vegetation or litter remained after the fire. The banks were scored and eroded by runoff down the banks and large lumps of soil and stones had fallen away from some vertical inclinations. Much of the soil was charred and in some places baked hard by the fire. No tree canopy remained after the fire.

Site 2 . The Cascades at the end of the walking trail

The Cascades is a deep, shaded gully with steep, rocky banks, small waterfalls and a year-round swiftly flowing stream. Larvae of Simulids (black flies), the adults of which provide prey for the spiders, are abundant on the rock surfaces of the rapids. Spiders were located on the northern (south facing) steeply sloping banks. Nests were generally situated in aggregations about half a metre to two and a half metres above the water line in pockets of moist, stable, loamy clay soil with some moss and lichen cover, amongst rocks and butts of vegetation. Some nests also occurred further up the slope, away from the actual banks, and in isolation in the shelter of tree butts or rock overhangs.

Prior to the fire the creek was well shaded by the canopy provided by an understory and taller trees, predominantly jarrah, red gum and wandoo. The banks supported a dense growth (see Fig. 11) of shrubby, low trees, predominantly *Trimalium* and *Gastrolobium* , herbaceous shrubs and grass tussocks (*Poa*) with *Gahnia* tussocks along the water's edge.

After the fire, no tree canopy, shrub layer or ground cover persisted (Figs12, 13) and the severely burnt soil was completely exposed and in some places "ceramicised", that is baked hard like clay tiles. Similar severely burnt banks were observed at a *Moggridgea* habitat in a creek running southward between Bluff Knoll, Mt Isongorup and Moongoongoonderup Peak (see Figs 14 , 15).

Neohomogona sites

Location and description of sites

Sites 1 and 2 were along The Cascades Walk trail. *Site 1* was located approximately 100M from the start of the trail, before the first creek crossing on a southwest facing slope. The soil was a coarse sand with sandstone rocks; the rock cover was about 40%. The dominant vegetation was an open forest of jarrah, redgum and wandoo with little understory apart from herbaceous shrubs prior to the fire. Following the fire there was no canopy but some regeneration (see Fig. 10 for general aspect).

Site 2 was further along the trail between the first and second creek crossings in a slight depression or saucer shaped hollow. The soil was a coarse sand without rocks and the vegetation similar to the first site.

Site 3 was a level area on a gently sloping shelf near the opening of a valley running south from between Bluff Knoll, Isongorup and Moongoongoonderup Peaks. The vegetation was open forest as above but with dense shrubby trees of *Acacia*, *Melaleuca* and others, *Kingia* and small shrubs. The soil was a deep, grey sandy loam without stones. Areas such as this appear to provide optimal habitat conditions, that is on the southern base of the Bluff Knoll complex, where the soil is deep, the habitat is shaded by the mountain bluffs and summer fogs and drizzle are common. Hence dense aggregations are found along the southern bases of the bluffs.

(b) *Toolbrunup (unburnt site)*

Moggridgea Site 3

The study site was located a few metres from the walking trail along a south facing bank of the main creek running out of the south east face of Mt Toolbrunup , at a point just below the large scree slope. The vegetation consisted of jarrah, red gum, wandoo forest with a now broken canopy which has obviously deteriorated partly as a result of sequential fires. A dense understory of *Gahnia* tussocks, blackboy, and shrubs of acacias, hakeas, *Tomacea* and hazel provided a complete, low canopy for the creek banks. The soil although shallow and mixed with stones, was generally a weathered tilth-like texture with a complete covering of moss. The last fire in the area was in 1980. The more or less vertical banks of the creek at the study site were about two metres high above which the ground sloped more gently upwards. Higher up the creek course the valley became a deeply incised gorge with on the incised side, vertical cliffs 15 to 20M high and heavily vegetated. At the study area the rocky creek bed was narrow , only two to three metres across.

Nests were located in pockets of mossy soil amongst the projecting rocks, tree butts and shrubs.

Neohomogona nests were sparsely scattered along the Toolbrunup path above the large scree slope. The species was also observed on Mt Magog and Talyuberup, thus extending the known locations (see Fig. 15).

Sampling methods

Eucyrtops

In order to ascertain the numbers of viable (i.e. surviving) nests in burnt sites, a five metre transect was selected on the bank (as described above) where one of us (BYM) had noted abundant nests in July and September 1990 (prior to the fire). Three grids of one square metre each were selected at random from a possible five. Nests were located by visual search for approximately ten minutes per grid. Data on density of nests and demography of the population was obtained by counting the nests and measuring the diameter of the trapdoors with draughting dividers and a millimetre steel rule.

No comparable populations were located for comparison in unburnt areas. A different species of *Eucyrtops* occurs on the western block of the ranges (BYM personal observations).

Moggridgea

To assess the effect of the fire on populations of *Moggridgea* , the density and demography of the populations from burnt and unburnt sites were compared. Sampling at each site involved the allocation of three grids of one square metre. At Site 1, a five metre transect was sited on the bank (approximately 20cm above the creek bed) where nests had previously been observed, and three grids were randomly chosen for sampling. However at Sites 2 and 3 (the latter unburnt), the distribution of nests was discontinuous and limited, and thus with no potential for randomness, three grids were placed over the aggregations as they were located. At Site 2, the distance between the two furthest grids was approximately 30m, at Site 3 the distance was approximately 10m. At these sites the distance between the creek bed and the lower edge of the grids varied from 10cm to approximately 4m, which resulted in heterogeneous microhabitat conditions - the grids at the greatest distance from the creek bed tended to contain less moisture and were prone to drying out.

Collection of data involved location of viable nests through one hour of visual search of each grid. As each nest was located it was marked with a coloured map tack to ensure that nests were not counted or measured twice. Due to difficulty of locating the well camouflaged and tiny nests, the initial one hour search was followed later by a half hour search to ensure that all nests were located. The diameter of each trapdoor was then measured with draughting dividers as for the *Eucyrtops* doors.

Neohomogona stirlingi

Sites 1 and 2 each comprised two 6m transects, along which five grids of one square metre were randomly chosen from a possible 12. Data on density of nests and demography of the population structure was collected by visual search of approximately 10 minutes to locate viable nests within each grid. The diameter of the entrance of each burrow was then measured with draughting dividers to obtain relative sizes of nests.

No comparable sites in unburnt areas were located for comparison.

In addition, potential prey for *N. stirlingi* was sampled along a line of five pit traps (plastic cups) parallel to and 2.5m distant from the *Neohomogona* transect. Pit traps were set 1m apart. Each contained about 250ml of Galt solution. Evaporation was high and required regular refilling. Traps were left open for 11 trapping nights.

General Collecting

Collection of invertebrates generally was made in both unburnt and burnt areas in order to assess species occurrence and comparative richness. The first site (burnt) was along The Cascades Walking trail in the vicinity of *N. stirlingi Site 1.* The second site (unburnt) was at the base of Toolbrunup along the path between the car park and *Moggridgea*

Site 3 , i.e. below the large scree slope. The techniques for collecting were visual search (night and day), beating of vegetation, overturning rocks and litter sampling. Leaf litter was collected by taking two or three handfuls of litter and storing it in a plastic bag which was sealed on the last field day. The fauna was later extracted through Berlese funnels at the laboratory. Spiders were identified to families and where possible to the genus. A list of spiders collected and collecting method is presented in Appendix 1.

Results and Discussion

Moggridgea

Density

The numbers of nests found within each area are presented in Table 1. Data from sites 1 and 2 were pooled into a single result for the burnt area and similarly data from site 3 were combined to give the unburnt result. The mean number of viable nests per square metre in the burnt area (mean +- SE: 22 +- 5.75) was significantly less than in the unburnt area (109 +- 21.38) (unpaired t-test; DF = 7, t-value = 5.33, p (2 tail) = .0011).

Population structure

The mean sizes of *Moggridgea* nests (as measured by the width of the door) as sampled in burnt and unburnt areas are given in Table 1. The nests from the burnt area (Site 2 data pooled) show no significant difference to those from the unburnt area (Site 3 data pooled) (unpaired t - test; t - value = .86 , p (2 tail) = .3928). Data from Site 1 was not used due to heterogeneity of grids within the site.

However there were detectable differences in the size structure of the populations, as illustrated in Fig. 1. The population structure was found to be dependent on the fire status (burnt or unburnt) of the area in which it was located. Examination of the frequency distributions (Fig. 1) and the results of chi-square analysis (Table 2) shows that there was an absence of smaller viable nests (i.e. with door widths of less than 4mm) in the burnt site relative to the population from the unburnt site. That the population structure including spiders with door diameter of 4 mm and above, were similar in both sampling areas further shows that the difference lies in the proportion of immature specimens in the population at each site.

N. stirlingi

Density

The mean number of nests found within each grid is presented in Table 3. Density in Grid 5 was significantly higher than that in all other grids except Grid 3. Grid 3 also had a significantly higher density than Grid 1. Variation within grids tended to be high. These results suggest a wide ranging density across sites which thus indicates that the spiders were distributed in discrete aggregations.

Different microhabitat conditions may have facilitated a heterogeneous response to the fire, with some aggregations exhibiting higher survival than others. However, it is also probable that the friable, deeper soil at Site 5 combined with a long daily period of shade due to the southern aspect and assured moisture content provided by summer fogs and drizzle, add up to an optimal habitat for the spiders thereby encouraging dense aggregations.

Population structure

The mean sizes of *N. stirlingi* nests (internal diameter of the palisade) are given in Table 3. Data from Grids 1 and 2 and from 3 and 4 were pooled.

The mean nest size was different at each site except between Sites 2 and 3, but was similar between all other sites (unpaired t- tests see Table 4).

The demographic structures of the populations are illustrated in Fig. 2. Real differences are indicated in the nature of the populations between sites, confirmed by chi-squared analysis (Table 5). Apparently some aggregations contained a high proportion of smaller nests (and therefore smaller spiders), while others exhibited a low proportion of small nests. These differences suggest that in some areas, juvenile spiders occurred in less numbers relative to adults. This probably reflects a fire-induced mortality.

Eucyrtops

Density

The number of viable nests recorded at the study site are presented in Table 6. The mean number of viable nests per square metre was 4 (+ 2).

Population structure.

The mean sizes (door width) of *Eucyrtops* are also given in Table 6 and the demographic structure shown in Fig. 4. There is a general indication of proportionately older (or "middle" aged) specimens, few very old (as would be expected) but relatively few very young specimens which would be unexpected in a "normal" population in that many recruits would be present.

Other species

Stanwellia sp.

A new species of the genus *Stanwellia* (family Nemesiidae) was discovered at The Cascades after the fire. Several tubes were found in pockets of soil protected by overhanging rocks in the north bank of the creek. This genus is a Gondwanan relic with its main distribution in southeastern Australia, southern South Australia including Eyre Peninsula, Tasmania and New Zealand. Elsewhere in W A it occurs in wet forest situations in the extreme southwest, in the Porongurup Range and West Cape Howe. It was not previously known from the Stirling Range. In that it has now been observed only at this one site it is assumed to be exceedingly rare. Another possible site is the deep valley running south from The Arrows.

It was presumably more abundant along the creek course of The Cascades prior to the burn. The tubes are shallow (4 - 6 cms), incorporate litter and debris and would have been destroyed in the litter and moss which would have provided the usual microhabitat for the genus.

General collection (see Appendix 1)

The spiders obtained from pitfall traps (*N. stirlingi* sites on The

Cascades Walking trail and Toolbrunup) and from visual searchs (burnt and unburnt sites) and litter samples from the unburnt site are listed in Appendix1. Arachnida and insects collected from pitfall traps only from burnt sites (Bluff Knoll, *N. stirlingi* Sites 1 and 2) are summarised in Table 7. Taxa are summarised at ordinal level except for family level of spiders. Only two species of mygalomorphs (males of*N. stirlingi* and *Chenistonia tepperi*) were collected, both from pitfall traps. Ten families of araneomorphs were represented. Eight families were collected from the unburnt area, seven from the burnt area. Two of the families (Oxyopidae and Zodariidae) collected from the burnt area (both from pitfall traps) were not observed in the unburnt area, and one of the families collected at the unburnt area was not represented amongst the burnt area collections (Gnaphosidae, generally corticolous/litter spiders).

Amongst the other taxa collected (pitfall traps from *N. stirlingi* sites on The Cascades trail - see Table 7), the species were predominantly beetles, flies and ants. Some of the ants and flies occurred in considerable numbers, for example 147 ants, 97 and 100 flies in traps from some transects. However none of the specimens were measured thus no assessment of actual prey availability was made.

Finally observations on one particular species, the social crab spider, *Diaea socialis* Main, are notable. This species in Western Australia is confined to the southwest forest region, occurring from about Manjimup to coastal areas west of Albany. Related forms (at present regarded as conspecific, but probably representing sa complex of related species) occur in south eastern Australia and Tasmania. The genetics of this interesting social spider are at present being investigated by a graduate student at Melbourned University (formerly from the University of Wesern Australia under the supervision of one of us (BYM)). The spiders occur in karri, jarrah and occasionally bullich trees. They make carton-like nests by webbing gum leaves together. Family groups of spiders live within these nests. Large, i.e. relatively mature nests have been noted to have some resistance to fire if subjected to moderate autumn or spring fires. However incipient nests containing females with eggs or juvenile spiders (generally late spring to early autumn) are highly vulnerable to fire. Nests were observed at both Toolbrunup and the Cascades prior to the 1991 fire. After the fire in which the eucalypt canopy was destroyed at most Bluff Knoll sites, no nests remained. It is doubtful if the spiders will recolonise on Bluff Knoll as they appeared to occur in naturally more or less isolated sub populations. To date other focal populations have not been located in the eastern block of the Ranges.

Discussion and Conclusions

Interpretation of the results reported above are coloured by certain constraints imposed in attempting to obtain a quantitative assessment of the effect of the recent fire on the population structure of the three species *Moggridgea sp.*, *Neohomogona stirlingi* and the *Eucyrtops* species. The sampling areas for both the relic species , *Moggridgea sp.* and *N. stirlingi* and for *Eucyrtops* were selected on the basis of earlier observations (by BYM) on the presence of the species prior to the 1991 fire. Although *Moggridgea* and *Eucyrtops* were not discovered until 1990 *Neohomogona stirlingi* occurrences in the Stirling Ranges were well known, some sites from as early as 1953 (Main 1985a). To obtain comparable quantitative results, availability of sites within the selected areas was limited by the presence of sufficient numbers of nests to provide data for statistical analysis.

However, from earlier observations (of BYM) it was apparent that the aggregations of spiders were patchily distributed according to favourability of microhabitats. For example along the creek banks where *Moggridgea* occurred dense aggregations within one or two square metres occurred adjacent to stretches of perhaps several metres with nests very sparsely distributed or absent, due to subtle differences in orientation, soil changes, rocks and other obstructions. That the most favourable microhabitats, particularly of *Moggridgea,* and to some extent of *Eucyrtops* were the most seriously affected by the fire, was fairly obvious. It was also apparent that the spiders in some such optimal microhabitats suffered almost total destruction.

To appreciate this apparent anomaly the biology of the spiders needs to be considered within an historical, biogeographic context. *Eucyrtops* is an autochthonous southwestern Western Australian genus, and possibly contemporaneous with the early Tertiary evolution of a sclerophyll, (partly *Eucalyptus*) dominated vegetation. Nevertheless the genus has been interpreted as the most "primitive", "earliest" and least "arid" adapted genus in the tribe Aganippini, and generally preferring moist, shaded habitats and "humid" refuguia even when occurring in otherwise arid habitats (Main 1957, 1962). However, both *Moggridgea* and *Neohomogona* are relics of a biological scenario which predated the advent of fire as a recurrent, natural phenomenon. Occurrence of both genera in southwestern Australia dates from at least as early as the Jurassic (*Moggridgea*) (Main 1991b) and Cretaceous (*Neohomogona*). It was not until the early Tertiary that a sclerophyll vegetation association became well established (e.g. primarily Proteaceae by the Palaeocene) while at the same time *Nothofagus* and associated rainforest vegetation continued to exist (see Lange, 1982 for discussion on early Tertiary vegetation associations). It can be surmised from the coincident occurrences of rainforest and sclerophyll vegetations for much of the early Tertiary that the genera considered here were at first restricted to the rainforest habitats and later, associated with recession of rainforest, to the wetter microhabitats within the sclerophyll forest as it became predominant.

Neohomogona , although affected adversely by fire with a reduction in the number of spiders in the younger cohorts leading to an aging population, shows more resilience in the short term than does *Moggridgea* .*Neohomogona* probably survives better in its preferred or optimal habitats (deep soil in tree-shaded, non rocky habitats or soil-filled depressions on the summits) than in non-optimal habitats (soil pockets on stony slopes and rock crags of mountain summits and "chimneys"). Paradoxically, *Moggridgea* has clearly survived less well following fire in its optimal habitats, i.e. in the deeply shaded creek banks of liverwort and moss covered loam, silt and clay soils.

Until the changes in the vegetation associations from rainforest to sclerophyll (eucalypt) dominance it was unlikely to have been fire-prone. Even now, the tingle forest particularly red tingle (*Eucalyptus jacksoni* Maiden) is not as predisposed to burning as are other eucalypt associations e.g. jarrah and karri. However, when tingle trees are burnt the effect can be catastrophic on relic invertebrate fauna. It has already been noted that in the Walpole/Nornalup area the "ideal" habitat for *Moggridgea tingle* is the thick, spongy , moss grown bark of the tingle trees. When the trees are burnt, although they generally survive, the outer decaying bark (which also harbours other invertebrates) is destroyed and the fauna is killed. Recolonisaation by *Moggridgea* is subsequently dependent on the time it takes for the bark to be replaced and the moss and other plant life to reestablish plus the reinvasion by *Moggridgea* spiderlings from surviving spiders in soil refugia. Even soil "refugia", as at the Deep River have been observed to be severely affected by fires with almost total destruction of nests in particular aggregations (Main 1991b).

Relic invertebrates such as the *Moggridgea* species were possibly already declining as a result of attrition by occasional "natural" fires before European intervention. However it is known that fire frequency has increased since European settlement. For example Lamont et al (1979) demonstrated that some Western Australian grass trees (*Xanthorhoea preissii* and *Kingia australis*) were burnt only three times and once during the 150 years prior to settlement but 22 and 12 times respectively in the first 150 years post settlement. It is the increased frequency of fire combined with the scale of area and reduction in the number of long -unburnt patches that is exacerbating the vulnerability of *Moggridgea* species in the tingle forest and Stirling Ranges. A significant continuing change in the optimal habitat, apart from immediate (if only temporary) structural change at ground level, is the inexorable change from a closed canopy to an increasingly fragmented and open canopy.

This is based on an invalid method

As shown above the "optimal" habitats of *Moggridgea* (i.e. those most like the hypothetical "original" Mesozoic/early Tertiary habitats) in the tingle forest of the Walpole/Nornalup area are the most vulnerable. Similarly the optimal miocrohabitats in the Stirling Range i.e. the wetter, deeply shaded creek banks close to permanent water which would not normally burn, are paradoxically the most vulnerable in the event of a hot summer fire. If the vegetation burns, then because of the moisture in the wet loamy or clay banks with their liverwort and moss cover, the soil is "cooked" through a "steam and bake" process to the point where whole clods of soil are "ceramicised". Spiders in the shallow burrows are killed. The soil of the slightly less luxuriant habitats appear not to be subject to such intense heating. Thus, as in the tingle forest, it is the "secondary" level habitats which have a higher survival of spiders. The sites studied were (a) at best, less than optimal habitats and possibly "marginal" but (b) because they were not as seriously affected (as spider habitats) relatively more spiders survived there than in the most favourable or "preferred" microhabitats.

Similarly the "best" *Eucyrtops* habitats were the most severely affected by the fire in that the wet clay soil, because of the intensity of the fire was "ceramicised" and the spiders were baked. This was apparent at several unsampled, creek bank sites.

Where it was possible to make quantitative assessments of populations, it is apparent that for both *Moggridgea* and *Neohomogona* the population structure has been affected. Relatively fewer juvenile spiders and particularly early cohorts i.e. possibly one to three year olds survived the fire. However large (full size) nests proportionately survived the fire better. Thus, where more than a very few nests survived, the adult spiders will probably be able to carry the population (at very reduced numbers) for several years until sufficient vegetation cover and invertebrate prey re-establish to accomodate future recruitment. Nevertheless it will probably take many generations (20-40 ? years) for *Moggridgea* to re-establish populations at the pre-1991 fire level and it is doubtful whether a hypothetical pre-European settlement abundance will ever be attained. A recount of nests, particularly of *Moggridgea* at the sampling sites in about five years (the estimated time for future cohorts to develop to at least sub-maturity) would give a better indication of the long term response of the spiders to *occasional* severe summer fire. If repeated within that time span it is doubtful whether the species would persist except in very small unburnt pockets.

While one could argue that because *Moggridgea* survived the fire better in marginal habitats we are therefore witnessing the selection of populations "adapting" to an increasingly common fire regime *it is more probable* that because of the increased fragmentation of the sub-populations and the gradual degradation of even the secondary and marginal habitats (through destruction of canopy and other associated habitat changes) that the species will decline and possibly become extinct *unless safeguarded through fire-exclusion in some favourable pockets.*

The problem for management is thus both philosophical and practical. Fire-exclusion from sites such as the south-east running creek on Mt Toolbrunup and The Cascades in the Bluff Knoll complex is feasible but obviously difficult. Nevertheless the ethical argument for "saving" selected relic invertebrates is as strong as that for saving selected vertebrates; *Moggridgea* is clearly as significant biogeographically as the short-necked tortoise. In a cultural sense, *Neohomogona stirlingi* and the species of *Moggridgea* are indeed biogeographic icons.

In terms of conservation ethics and in the context of sustainable biodiversity there is an obligation to protect the endemic, biogeographically significant species of *Moggridgea* and *Neohomogona* .

Recommendations for Conservation and Management

Fire exclusion or low intensity controlled burns only and at very infrequent intervals would seem to be the prime concern for conservation of *Moggridgea* and *Stanwellia.* If fire is to continue to be used as a fuel reduction procedure then low intensity control fires only are recommended and at very infrequent intervals at both *Neohomogona* and *Eucyrtops* sites. Optimal habitats of *Neohomogona* (deep sandy/loam soils which enable spiders to dig deep burrows) are less adversely affected by fire than are rocky sites.

Moggridgea

(1) Any prescribed burning should avoid (or be light burns only) in the following areas:

(a) The deep shaded gullies on Bluff Knoll (e.g. The Cascades and the creeks crossing the walking trail to the Cascades). These areas were severely burnt during the 1991 fire but are revegetating. As it may take 20 -40 years for the *Moggridgea* populations to re-establish they should be protected from fire for at least this lenghth of time.

(b) Creeks of the southern faces of Bluff Knoll, Moongoongoonderup, Isongorup and The Arrows (e.g. Mirlpunda)

(c) The deep south east gully running from Mt Toolbrunup (running from above and towards the car park; the walking path runs alongside this gully - there is a good population in the creek bank near the path and just below the large scree slope which the path skirts).

(2) If burning is to be undertaken in the above areas then it is recommended that:

(a) Avoid burning or scorching the tree canopy in order to prevent undue leaf fall which would thin the canopy and reduce shade/shelter.

(b) Avoid scorching of creek banks which harbour spider burrows.

(3) A survey should be made to (i) locate and map in detail all known sites where *Moggridgea* occurs and (ii) deliberately search likely places to make a comprehensive site-occurrence of the distribution of the species. Sites should be marked (with steel "droppers") so that at least some sites can be protected in the event of controlled (or accidental) fires.

(4) (a) As The Cascades becomes revegetated, the banks (particularly the

north banks which are naturally shaded) should be protected from visitor misuse e.g. sliding down to the creek. If access to the stream bed is to continue then steps should be constructed to discourage indiscriminate scrambling over the bank. Wooden or steel steps *over* the bank would be preferable so that spiders can continue to build nests underneath)

Access to the stream bed would be better placed farther down stream than at present as the bank of the present access is where the densest spider populations are sited. While recognising that this is an attractive stream for visitors then the path itself could continue up the valley providing it is kept away from the actual declivity of the bank.

[It is worth noting that at Beedelup Falls the formal, graded path on the "far" side of the water course has a population of another rare species of trapdoor spider (*Arbanitis* sp.) in the more or less vertical banks on the upslope of the path - trapdoor spider habitats can be maintained in spite of visit0r use if paths are well constructed and formalised].

(5) If control burning is to continue then efforts should be made to exclude burning (a) the north banks of The Cascades (near the present access) up and down stream from the waterfall and fallen log crossing and (b) other creeks near the crossings of the Cascades walking trail (c) banks near the stream bed of the south-east creek on Mt Toolbrunup.

Special protection of *Moggridgea* populations in the event of a fire could be ensured by "wrapping" small (populated) areas of ground with wet hessian sheeting.

Neohomogona

If control burning is to be used as part of fuel reduction management procedures then they should be of long periodicity - preferably not less than 20 and in selected sites, 40 or more years intervals e.g. woodlands along The Cascades walking trail, creeks on south east aspect Bluff Knoll massif, south base of Bluff Knoll massif. The Toolbronup Peak should be protected from fire.

Eucyrtops

The Bluff Knoll walking path between the junction with the Cascades path and the creek crossing "dog leg" should be protected from fire. The slope above the path which has several populations of *Eucyrtops* should not be cut into unless it is carefully examined for presence of aggregations of nests.

At The Cascades as for *Moggridgea.* Where the northern slopes above the actual creek banks are revegetating avoid burning for 20 (?) years to allow reestablishment of population in sheltered sites such as below jutting rocks and logs.

Social crab spiders - *Diaea socialis*

It is doubtful whether any spiders survived the fire in the Cascades area, however on Mt Toolbrunup protection from fire in the southeast gully (up which the walking path is directed) should ensure persistence of some spiders in this subpopulation. It is worth noting that light to moderate fires from late autumn to early spring are less likely to damage nests than for example summer fires. This is when spiders are aggregated in relatively large communal nests which due to the "packing" of the eucalypt leaves the nests are less vulnerable to burning.

If further nests are sighted *anywhere* in the Range the sites should be identified and recorded. If possible the canopy of such sites should be protected in the event of control burning.

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Tables

Table 1. Summary of *Moggridgea sp.* nest size data (door width) for all sites. December 1991 sample.

locality	mean	SD	SE	count
Burnt				
grid 1.1	.65	0	0	1
grid 1.2	.45	.11	.02	31
grid 1.3	.52	.10	.02	31
grid 2.1	.44	.11	.02	39
grid 2.2	.44	.14	.04	14
grid 2.3	.43	.12	.03	16
Unburnt				
grid 3.1	.44	.15	.02	68
grid 3.2	.48	.20	.02	140
grid 3.3	.44	.18	.02	119

Table 2. Chi-squared analysis of *Moggridgea sp.* population structure from burnt and unburnt areas.

	total chi-square	probability
Category 1	22.59	.0001
.2<=x<.4		
.4<=x<.6		
.6<=x<.8		
.8<=x<=1.0		
Category 2	5.96	.1137
.2<=x<=.4		
.4<x<=.6		
.6<x<=.8		
.8<x<=1.0		

Table 3. Summary of *N.stirlingi* density data for all sites, December 1991.

locality: site	locality: grid	mean nest count	standard error	standard deviation	mean nest size (palisade diam. (cm))
1	1	2.2	.37	.84	.945
1	2	3.6	1.44	3.21	.908
2	3	10.8	1.83	4.09	.598
2	4	9.2	3.77	8.44	.577
3	5	18	4.66	10.42	.551

Table 4. Unpaired t-tests on door width data of *Moggridgea* between grids

site	site 1	site 2
1	x	
2	7.973***	x
3	7.188***	1.091

Table 5. Chi-squared analysis of *N.stirlingi* population structure.

sites	total chi-square	probability
1 vs 2	60.799	.0001
3 vs 1	43.081	.0001
3 vs 2	16.076	.0029

Table 6. Summary of *Eucyrtops sp.* density and nest size data.

Locality Square	N	Door Width Mean (SE)
1	8	1.69 (.09)
2	2	1.55 (0)
5	2	1.62 (.02)
Overall Mean (SE)	4 (2)	1.66 (.06)

Table 7. Data on invertebrate fauna from pitfall traps at *N.stirlingi* study sites one and two on Bluff Knoll, Stirling Ranges, during early stage post-fire recovery (November, 1991).

Species-taxon	Bluff Knoll Site 1		Site 2	
Transects	1	2	3	4
Chelicerata				
Arachnida				
Pseudoscorpionida (1sp)	0	0	1	0
Acarina (4spp)	3	7	6	6
Araneae				
Mygalomorphae				
Ctenizidae				
Neohomogona stirlingi Main	0	0	0	1
Nemesiidae				
Chenistonia sp.	1	1	0	0
Araneomorphae				
Salticidae (6spp)	1	2	1	2
Clubionidae (1sp)	0	1	1	2
Zodariidae (1sp)	0	1	0	0
Oxyopidae (1sp)	0	1	0	0
Micropholcommatidae (1sp)	0	0	1	0
Desidae (1sp)	0	0	1	1
?Orsolobidae (1sp)	0	0	0	1
Uniramia				
Hexapoda				
Collembola (1sp)	2	0	60	43
Insecta				
Blattodea (1sp)	0	1	0	0
Lepidoptera (1sp)	2	1	1	0
Hemiptera				
Homoptera (7spp)	3	0	5	11
Coleoptera (15spp)	16	7	4	6
Diptera (22spp)	97	64	58	100
Hymenoptera (27spp)	152	59	59	54
(Formicoidea (10spp))	(147)	(54)	(51)	(48)
?Isoptera (1sp)	2	0	0	0
Neuroptera (1sp)	1	1	0	1
Orthoptera (1sp)	2	2	0	1
Plecoptera (1sp)	0	1	1	0

Figures

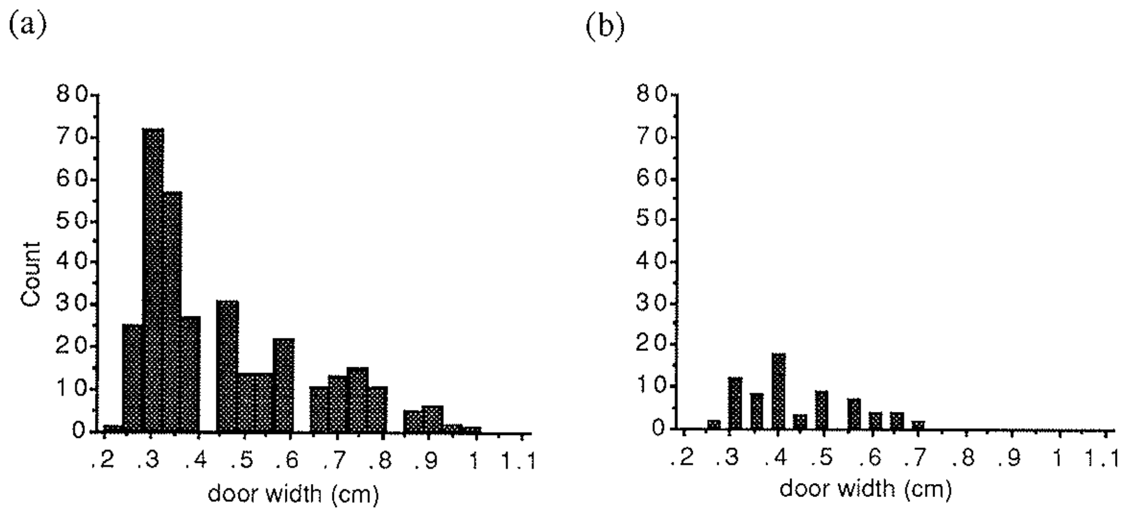

Figure 1. Frequency distribution (with 20 intervals) showing population structure of *Moggridgea sp* at (a) site 3 (unburnt) and (b) site 2 (burnt).

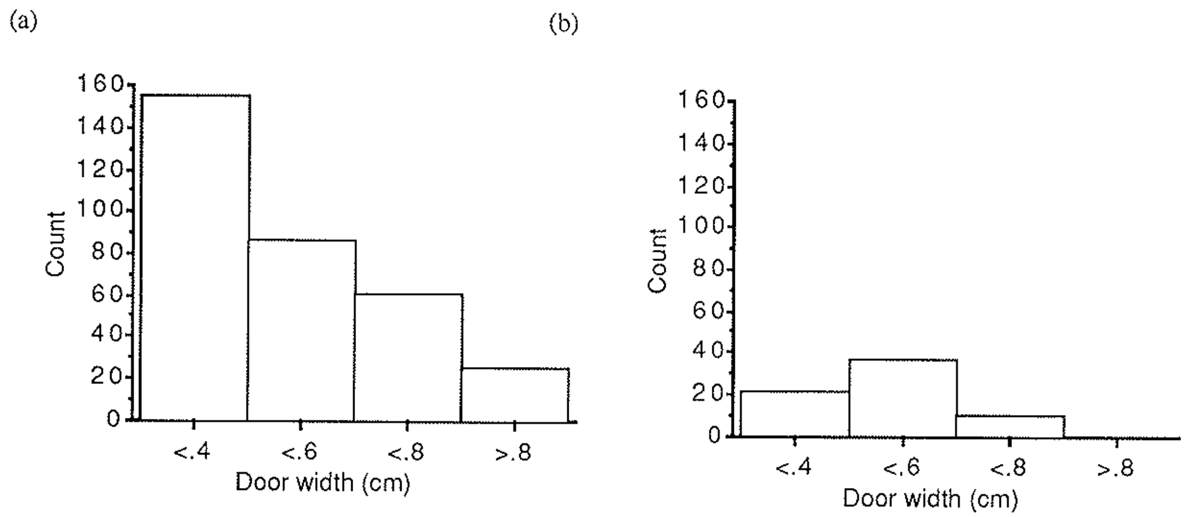

Figure 2. Frequency histogram for category 1 of *Moggridgea sp.* in (a) site 3 - unburnt and (b) site 2 - burnt.

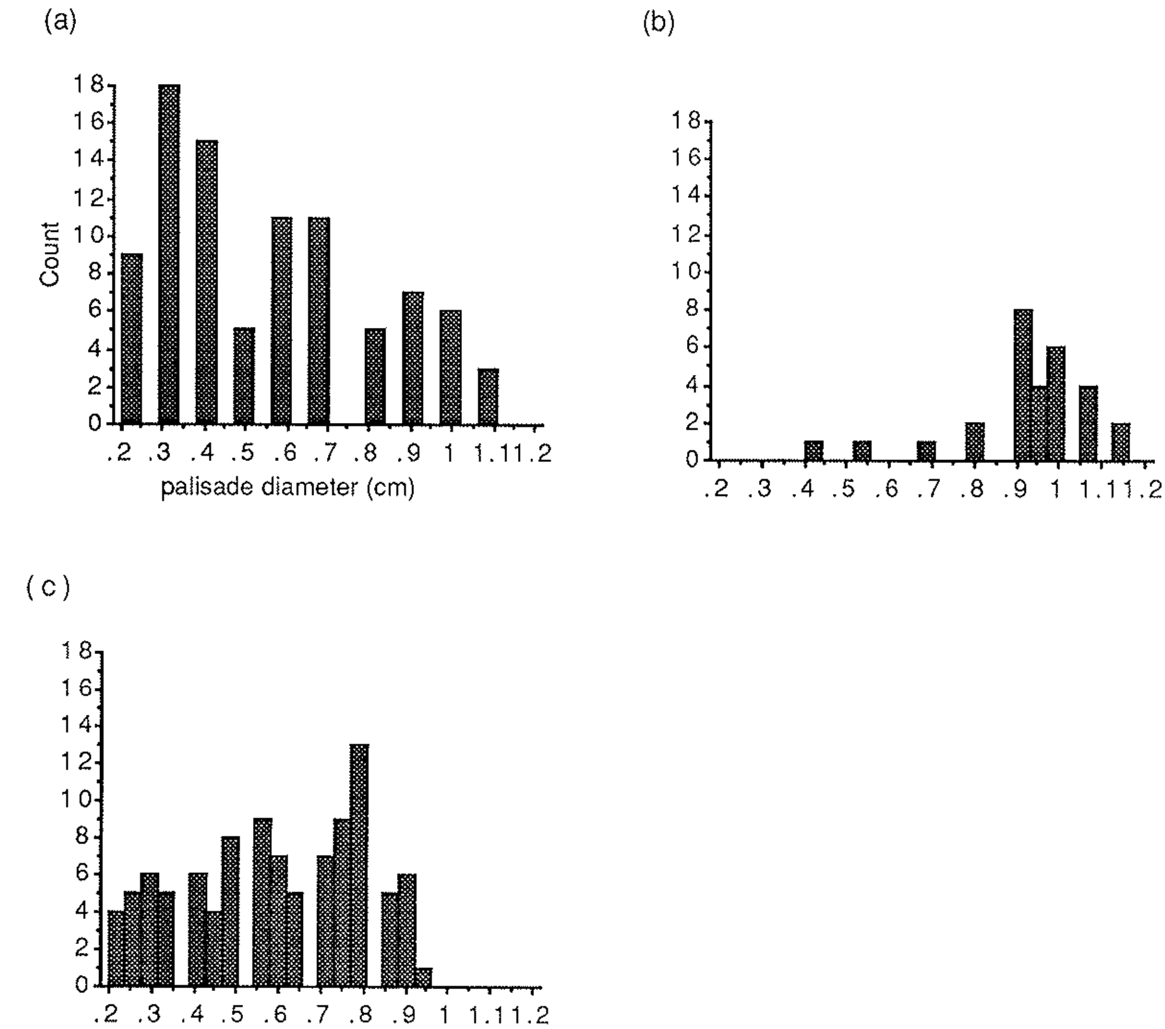

Figure 3. Frequency distribution showing population structure of *N.stirlingi* at (a), grid 5, and (b) grids 1 and 2 pooled, and (c) grids 3 and 4 pooled.

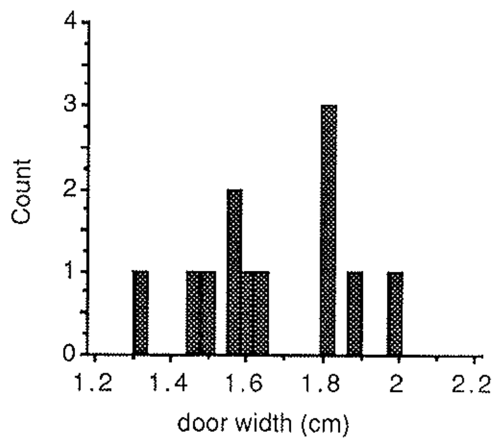

Figure 4. Frequency distribution showing population structure of *Eucyrtops sp.* sampled at Bluff Knoll.

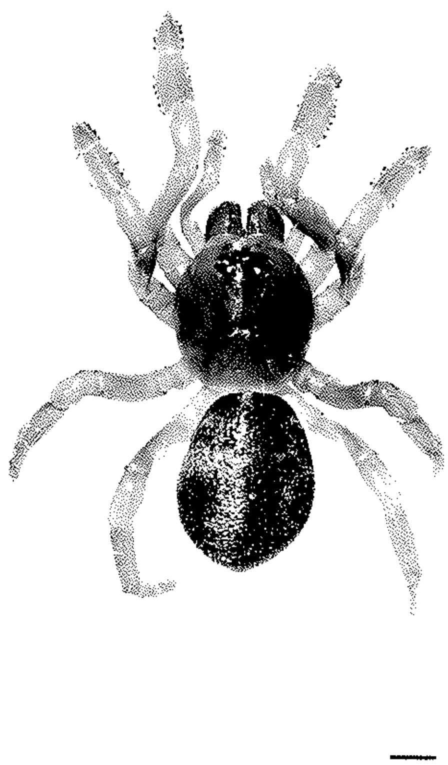

Figure 5. *Moggridgea* sp., dorsal view of female spider. Scale:1.0mm

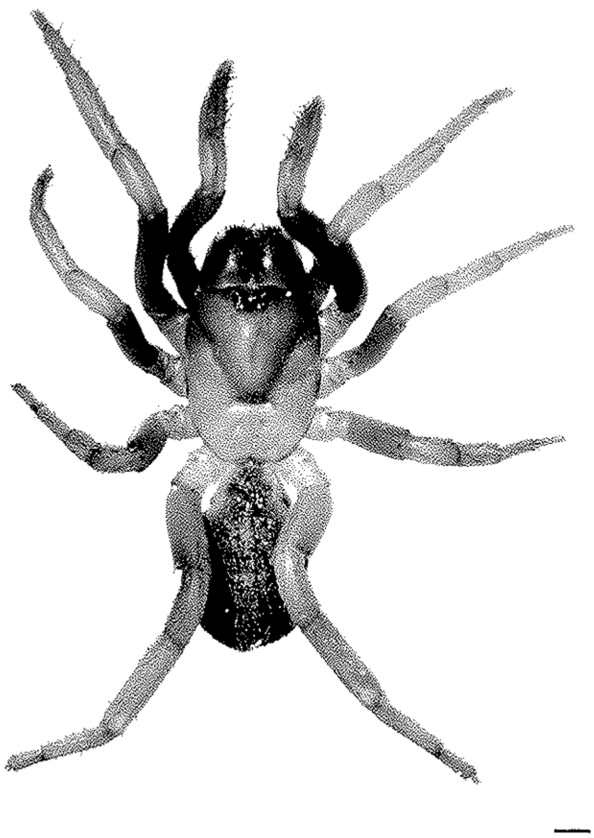

Figure 6. Neohomogona stirlingi, dorsal view of female spider.Scale: 1.0mm.

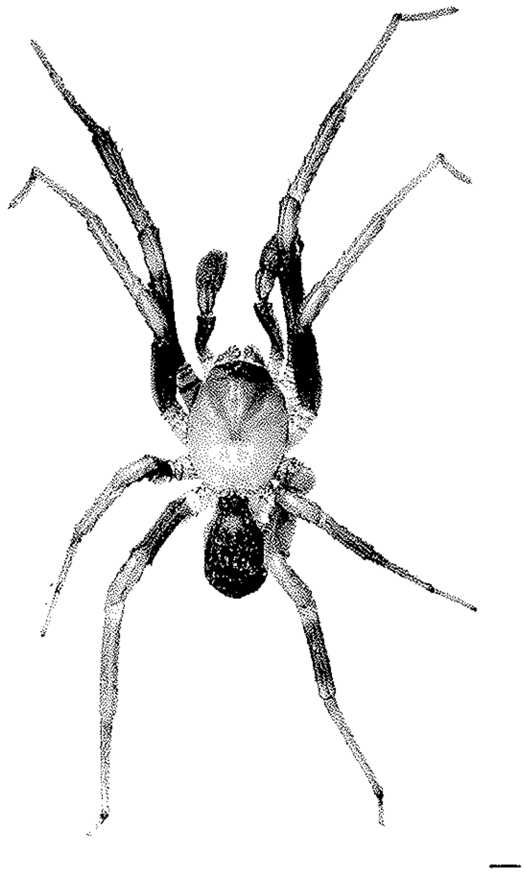

Figure 7. Neohomogona stirlingi, dorsal view male spider. Scale: 1.0mm.

Figure 8. Palisade entrances of burrows of Neohomogona stirlingi. Note three burrows, various sizes.

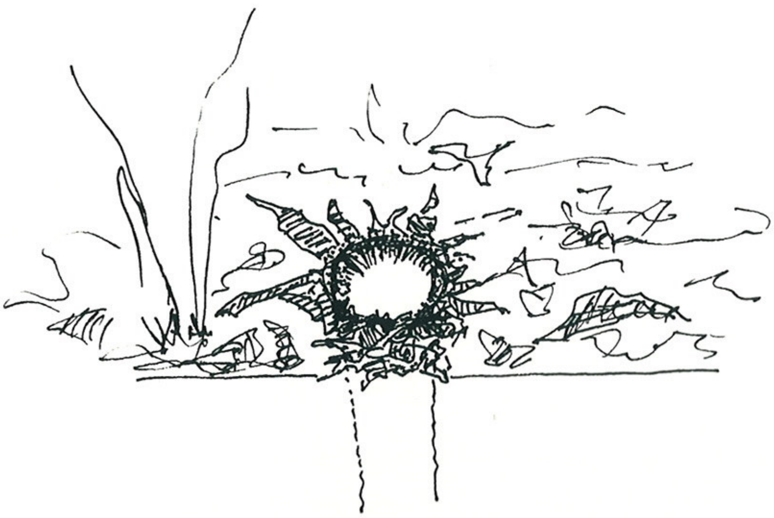

Figure 9. Bluff Knoll, general view of west/southwest aspect, seven months after fire. Note walking path.

Figure 10. Open forest along Cascades walking path, looking towards Bluff Knoll, showing canopy loss and epicormic growth. Seven months after fire.

Fig. 11.

Fig. 12

Figure 11. The Cascades, looking up gorge from near end of walking path. September 1990, prior to fire, showing dense, low vegetation along banks and higher canopy.
Figure 12. The Cascades, seven months after the fire from approximately same place as above. Note loss of canopy and ground cover.

Figure 13. Moggridgea habitat at The Cascades, view of bank seven months after fire. Site was formerly well covered with moss and shaded by shrubs and tree canopy. Note exposure and erosion of bank.

Figure 14. Moggridgea habitat, creek south of Isongorup/Bluff Knoll, seven months after fire.Note severed exposure of phyllite slabs and soil. A single viable nest observed in about 3M long section (indications of previous abundant nests i.e. burnt and exposed burrows).

Figure 15. Map of the Stirling Range National Park showing observed distribution of Moggridgea ●, and Neohomogona stirlingi ■ Data from BYM earlier records and recent observations of BYM and KG. this study.

Appendix 1. Spiders collected by visual search, beating vegetation, litter samples and pitfall traps from unburnt and burnt areas.

number	family	genus	details
SR 001	Nemesiidae Sp 1	*chenistonia*	pit trap 1.3
SR 002	Nemesiidae Sp 1	*chenistonia*	pit trap 2.1
SR 003	Ctenizidae Sp 1	*Neohomogona stirlingi*	pit trap 4.5
SR 004	Clubionidae Sp 1		pit trap 2.1
SR 005	Clubionidae Sp 1		pit trap 4.5
SR 006	Clubionidae Sp 1		pit trap 3.3
SR 007	Clubionidae Sp 1		pit trap 4.1
SR 008	Salticidae Sp 1		pit trap 2.2
SR 009	Salticidae Sp 1		pit trap 1.3
SR 010	Salticidae Sp 1		pit trap 3.2
SR 011	Salticidae Sp 2		pit trap 2.2
SR 012	Salticidae Sp 3		pit trap 4.1
SR 013	Salticidae Sp 4		pit trap 4.5
SR 014	Zodaridae Sp 1		pit trap 2.5
SR 015	Oxyopidae Sp 1		pit trap 2.2
SR 016	Araneidae Sp 1	*Singotypa*	curled leaf spider. Talyberlup 11/12/91 Immature male.
SR 017	Araneidae Sp 1	*Singotypa*	As for SR 016. Yetermerup 11/12/91. Mature male.
SR 018	Nicodamidae Sp 1		Moggridgea site 3, 04/12/91, day. Found wandering on south facing bank.
SR 019	Araneidae Sp 2	*?Singotypa*	Similar to Araneidae Sp 1, but darker abd with different pattern. Neohom. site 1, 11/12/91 night.
SR 020	Amaurobiidae Sp 1	*Badumna*	Moggridgea site 3 stone search, 09/12/91, day.
SR 021	Salticidae Sp 6		Moggridgea site 3 stone search, 09/12/91, day.

SR 022	Salticidae Sp 6		Moggridgea site 3 stone search, 09/12/91, day.
SR 023	Araneidae Sp 3	*?Eriophora*	two anterior abdominal humps, pink, brown and cream. Moggridgea site 3 visual, arboreal search, 09/12/91 day.
SR 024	Araneidae Sp 3	*?Eriophora*	Moggridgea site 3 visual, arboreal search, 09/12/91 day.
SR 025	Araneidae Sp 3	*?Eriophora*	Moggridgea site 3 visual, arboreal search, 09/12/91 day.
SR 026	Araneidae Sp 3	*?Eriophora*	Moggridgea site 3 visual, arboreal search, 09/12/91 day.
SR 027	Araneidae Sp 3	*?Eriophora*	juvenile Moggridgea site 3 visual, arboreal day search, 09/12/91.
SR 028	Thomisidae Sp 1		Eyes outlined in white, small, light brown, abdomen with spotted pattern, which appears to fade with maturity. Moggridgea site 3 visual, arboreal day search, 09/12/91.
SR 029	Araneidae Sp 4		Bright yellow, small, globuse abdomen. Moggridgea site 3 visual, arboreal day search, 09/12/91.
SR 030	Araneidae Sp 5		Long anterior legs, greenish hue to eyes and carapace. Toolbrunup path visual, arboreal night search, 11/12/91.
SR 031	Araneidae Sp 6		Long abdomen, legs banded green and black. Toolbrunup path visual, arboreal night search, 11/12/91.

SR 032	Clubionidae Sp 2	*Clubioninae*	Uniformly light tan with darker stripe down abdomen. Toolbrunup path visual, arboreal night search, 11/12/91.
SR 033	Thomisidae Sp 1		Toolbrunup path beating bushes.
SR 034	?Araneidae Sp 7		Toolbrunup path beating bushes.
SR 035	Clubionidae Sp 2	*Clubioninae*	Toolbrunup path beating bushes.
SR 036	Clubionidae Sp 2	*Clubioninae*	Toolbrunup path beating bushes, 06/12/91.
SR 037	Theridiidae Sp 1		Short, stumpy legs, 3 tarsal claws, large, pearly PME with black and white flecks on abdomen. Toolbrunup path beating bushes, 06/12/91.
SR 038	Theridiidae Sp 1		As for SR 037 but pink overall. Toolbrunup path beating bushes, 06/12/91.
SR 039	Theridiidae Sp 1		Toolbrunup path beating bushes, 06/12/91.
SR 040	Theridiidae Sp 1		Toolbrunup path beating bushes, 06/12/91.
SR 041	Theridiidae Sp 2		Grey, long spines on legs, slightly pointed abdomen, otherwise as for Sp 1. Toolbrunup path beating bushes, 06/12/91.
SR 042	Amaurobiidae Sp 2a	*Badumna*	Smaller than Sp 1, differing carapace and abdominal patterns. Neohomogona site 2, visual day search, 07/12/91.
SR 043	Amaurobiidae Sp 2a		Neohomogona site 2, visual day search, 07/12/91.
SR 044	Salticidae Sp 7		Similar shape to Sp 1, but differing carapace and abdominal patterns. Neohomogona site 2, visual day search, 07/12/91.
SR 045	Salticidae Sp 8		Dark overall, with hairless, slightly elongated abdomen. Neohomogona site 2, visual day search, 07/12/91.

SR 046	Amaurobiidae Sp 2b	*Badumna*	Strongly banded legs, red/brown abdomen. A more striking specimen than 042 or 043. Neohomogona site 2, visual day search, 07/12/91.
SR 047	Araneidae Sp 8		Black with distinct abdominal pattern, two posterior abdominal humps. Neohomogona site 2, visual day search, 07/12/91.
SR 048	Araneidae Sp 8		Neohomogona site 2, visual day search, 07/12/91.
SR 049	Thomisidae Sp 1		Neohomogona site 2, visual day search, 07/12/91.
SR 050	Amaurobiidae Sp 2b		Toolbrunup path visual night search, 06/12/91.
SR 051	Amaurobiidae Sp 2b		Toolbrunup path visual night search, 06/12/91.
SR 052	Amaurobiidae Sp 2c		Toolbrunup path visual night search, 06/12/91.
SR 053	Gnaphosidae Sp 1	*Lampona*	Toolbrunup path visual night search, 06/12/91.
SR 054	Amaurobiidae Sp 2a	*Badumna* Sp 2	Toolbrunup path visual day search , 06/12/91.
SR 055	Amaurobiidae Sp 2a	*Badumna* Sp 2	Toolbrunup path visual day search , 06/12/91.
SR 056	Clubionidae Sp 2	*Clubioninae*	Toolbrunup path visual day search , 06/12/91.
SR 057	Araneidae Sp 1	*Singotypa*	Toolbrunup path visual day search , 06/12/91.
SR 058	Amaurobiidae Sp 2a	*Badumna* Sp 2	Toolbrunup path visual day search , 06/12/91.
SR 059	Amaurobiidae Sp 2a	*Badumna* Sp 2	Toolbrunup path visual day search , 06/12/91.
SR 060	Amaurobiidae Sp 2a	*Badumna* Sp 2	Toolbrunup path visual day search , 06/12/91.
SR 061	Amaurobiidae Sp 2a	*Badumna* Sp 2	Toolbrunup path visual day search , 06/12/91.
SR 062	Araneidae Sp 9		Small, light buff, similar to Sp 3 but without pink colouring and differing abdominal pattern. Toolbrunup path visual day search , 06/12/91.
SR 063	Araneidae Sp 10		Small, pink globose abdomen with white pattern. Toolbrunup path visual day search , 06/12/91.
SR 064	Clubionidae Sp 2	*Clubioninae*	
SR 065	Clubionidae Sp 3	*?Corinnomma*	Toolbrunup path leaf litter sample 1, Dec. '91.
SR 066	Araneidae Sp 11	*Eriophora Sp 1*	Large orb weaver, hairy cephalic area. Mt Hassell general collection 09/12/91.

SR 067	Araneidae Sp 12	*Araneus Sp 1*	Lightly haired cephalic area, medium to large. Mt Hassell general collection 09/12/91.
SR 068	Araneidae Sp 12	*Araneus Sp 1*	Mt Hassell general collection 09/12/91.
SR 069	Araneidae Sp 12	*Araneus Sp 1*	Mt Hassell general collection 09/12/91.
SR 070	Araneidae Sp 12	*Araneus Sp 1*	Mt Hassell general collection 09/12/91.
SR 071	Araneidae Sp 13	*Araneus Sp 2*	Mt Hassell general collection 09/12/91.
SR 072	Araneidae Sp 19		Spiderling, nondescript, light buff to light pink, some with white abdominal spots. Mt Hassell general collection 09/12/91.
SR 073	Thomisidae Sp 2		Smooth, unpatterned cephalic area and patterned abdomen 2 forelegs red, 2 hindlegs green. Toolbrunup beating bushes 06/12/91.
SR 074	Thomisidae Sp 3		2 broad stripes on cephalic area. Toolbrunup beating bushes 06/12/91.
SR 075	Clubionidae Sp 2		Toolbrunup beating bushes 06/12/91.
SR 076	Clubionidae Sp 2		Toolbrunup beating bushes 06/12/91.
SR 077	Clubionidae Sp 2		Toolbrunup beating bushes 06/12/91.
SR 078 to 086	Araneidae Sp 19		Toolbrunup beating bushes 06/12/91.
SR 087 to 094	Araneidae Sp 14		Toolbrunup beating bushes 06/12/91.
SR 095	Araneidae Sp 15	*?Araneus*	Lime, green abdomen. Specimen penultimate male. Toolbrunup beating bushes 06/12/91.
SR 096	Araneidae Sp 12		Toolbrunup beating bushes 06/12/91.
SR 097 to 098	Araneidae Sp 16		Spiderlings of mostly dark or black colouring with broad white bands on legs. Toolbrunup beating bushes 06/12/91.

SR 099 to 100	Araneidae Sp 17	Spiderlings of pale colouring with black and white pattern on abdomen. Toolbrunup beating bushes 06/12/91.
SR 101 to 102	Araneidae Sp 18	Pale spiderlings. Body covered in dark hairs, white pattern on abdomen. Toolbrunup beating bushes 06/12/91.
SR 103 to 104	Clubionidae Sp 2	Toolbrunup beating bushes 06/12/91.
SR 105	Araneidae Sp 14	Toolbrunup beating bushes 06/12/91.
SR 106 to 107	Araneidae Sp 16	Toolbrunup beating bushes 06/12/91.
SR 108 to 109	Thomisidae Sp 4	Small, rich brown, complex pattern on carapace. Toolbrunup beating bushes 06/12/91.
SR 110 to 115	Araneidae Sp 19	Toolbrunup beating bushes 06/12/91.
SR 116	Araneidae Sp 18	Toolbrunup beating bushes 06/12/91.
SR 117 to 118	Thomisidae Sp 1	Adult female and a juvenile. Toolbrunup beating bushes 06/12/91.
SR 119	Araneidae Sp 20	Small to medium sized, Triangular shaped abdomen with pink/cream pattern. Eyes 2.2.4. Broad, pink cepahalic stripe Toolbrunup beating bushes 06/12/91.
SR 120	?Araneidae Sp 21	Medium sized, legs spinose, eyes 4.4 with posterior row recurved. Pink/white abdominal pattern, some pink on cephalic area. Toolbrunup beating bushes 06/12/91.
SR 121	Araneidae Sp 12	Mogg site 1 (Cascades) visual day search 07/12/91.
SR 122	Araneidae Sp 16	Mogg site 1 (Cascades) visual day search 07/12/91.
SR 123 to 126	Amaurobiidae Sp 2b	Mogg site 1 (Cascades) visual day search 07/12/91.