DEMOGRAPHY OF THE SHIELD-BACK TRAPDOOR SPIDER *IDIOSOMA NIGRUM* MAIN IN REMNANT VEGETATION OF THE WESTERN AUSTRALIAN WHEATBELT

B. Y. MAIN

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The shield-back trapdoor spider *Idiosoma nigrum* Main (Araneae: Mygalomorphae: Idiopidae) is endemic to semi-arid southwest Western Australia. It ranges from Nerren Nerren Station in the north and through the central wheatbelt where its distribution is fragmented by agriculture. A natural history and demographic study at East Yorkrakine Nature Reserve over ten years indicates a population decline possibly associated with deterioration of the habitat through impact by rabbits, galahs and secondary salinity. Burrows within a 25 m by 53 m plot in open eucalypt woodland were individually pegged between 1987 and 1994. Spiders were categorised into three age groups (indicated by burrow entrance dimensions) and censused several times a year. Counts of the pegged burrows were also made in three later years. Another population in remnant vegetation on private land affected by secondary salinity from the 1960s is now almost extinct. Prognosis for populations elsewhere low in the landscape is poor. Persistence of spiders in habitats on high topography is possible in the short to medium time scale. Morphological variation associated with increased adaptation to xeric habitats in the outer regions of the geographic range is noted. Thus it is important to conserve populations over the entire geographic range if the genetic and adaptive diversity of the species is to be maintained.

B. Y. Main, School of Animal Biology M092, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia. [bymain@cyllene.uwa.edu.au]

The shield-back trapdoor spider, *Idiosoma nigrum* Main (Fig. 1) so called because of its heavily sclerotised dorsal abdominal integument, is one of the most highly arid-adapted Australian mygalomorph spiders (Main 1982). Several behavioural attributes and morphological features contribute to its survival in semi-arid woodland habitats: (a) the habit of attaching 'twig-lines' to the rim of the burrow (Fig. 2) increases the foraging area and is of significance in habitats where prey is scarce, localised or seasonal (Gray 1968; Main 1957, 1978, 1986); (b) a deep burrow in which an equable basal temperature and humidity is provided (Gray 1968); (c) a sclerotised abdominal cuticle (Fig. 1) which minimises evaporative water loss (and with which it also plugs the upper section of the burrow); (d) enlarged eyes which increase visual acuity and relatively long legs that facilitate 'hunting' activity (Main 1962).

The species, which was first discovered and described in 1952 (Main 1952), has a broad geographic range throughout what is now the central and northern wheatbelt of southern Western Australia (Fig. 22 in Main 1957) and extends north of the Murchison River to Zuytdorp and Nerren Nerren Station Pastoral Lease (Main et al. 2000). Spiders occur generally in eucalypt woodlands on heavy clay soils and occasionally in acacia dominated vegetation associations on granite soils. During the last century most of the favourable habitats, eg low lying woodlands, were cleared for cereal growing and hence populations of *I. nigrum* are now confined mostly to bushland in nature reserves, on road verges or remnants on private property. The long term viability of many of these sites is in jeopardy because of widespread secondary salinisation which is associated with rising water tables (including sites within gazetted nature reserves (George et al. 1996; Salama & Bartle 1995)). Observations at two sites, North Bungulla Nature Reserve (31°32'S, 117°39'E) and a nearby farm 'Fairfields', indicate that population numbers of *I. nigrum* have declined at these sites (Main 1987, and later unpublished observations). Because of its perceived rarity *I. nigrum* is currently declared as threatened under the Wildlife Conservation Act of Western Australia.

The discovery of a population of *I. nigrum* with a range of age classes at the East Yorkrakine Nature Reserve in 1987 prompted me to begin a monitoring study on the demography of the population in the hope of providing some general conservation guidelines for the species in other remnant habitats.

Materials And Methods

The 81 ha East Yorkrakine Nature Reserve (31°24'S, 117°35'E) is situated in the Kellerberrin Shire in the central wheatbelt of Western Australia. The area falls within a region subjected to mild wet winters and hot dry summers which are frequently ameliorated by rain-bearing thunderstorms. The average annual rainfall is 334 mm. Soils vary from yellow sand overlying laterite to heavy clay and with some flat granite exposures. The vegetation comprises two main associations of shrubland/heath and mallee/woodland with a small component of woodland (Muir 1980). The remnant has been a nature reserve since 1950 (Chapman 1980) and has never been cleared or grazed. Incursions due to rubbish have had minimal overall effects.

There is a 15 m fall in elevation going south to north in the reserve over a distance of 0.75 km. The study site is in the lowest part of the reserve and there is a further fall of 5 m to the base of the broad drainage valley of cleared farmland. From the cleared sandplain south of the reserve there is a 20 m fall from 350 m to 330 m along the southern edge of the reserve (Anon. 1984). Thus topographically the reserve lies towards the lower end

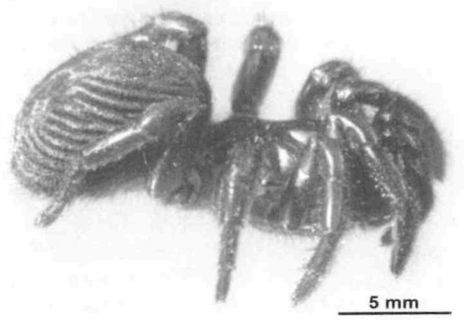

FIGURE 1. Profile of female of *Idiosoma nigrum*. Scale bar = 5 mm.

FIGURE 2. Burrow entrance with door open of *I. nigrum*. Fan of attached twig-lines enlarge the foraging area. Scale bar = 10 mm.

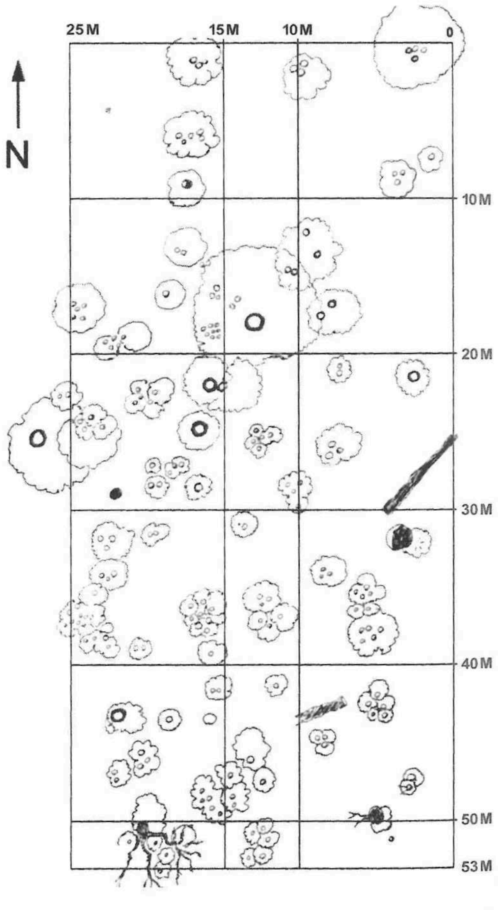

FIGURE 3. Plan view of study site at East Yorkrakine Nature Reserve showing stems of trees and outline of canopy which equates to area of permanent litter cover where most of the burrows are situated.

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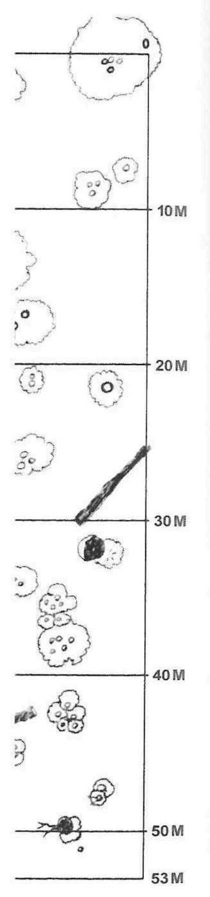

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of a 40 m gradient. The lower terrain was cleared just before World War I but the upslope area to the south remained uncleared until about 1960.

The remnant had not been burnt for a period of over 80 years, i.e. since agricultural settlement. However, in 1988, 1989 and 1991, as part of a study on reserve management, researchers in the Wildlife and Ecology Division of CSIRO with compliance from the Department of Conservation and Land Management (CALM) initiated a project on the response of bushland following fire. Two experimental fires were conducted in the nearby Durokoppin Nature Reserve (31°24'S, 117°42'E) in the autumn of 1988 and 1989 and one in East Yorkrakine (EYR) in autumn 1991. Although the woodland and part of the mallee-dominated vegetation associations in EYR were not burnt the rest of the reserve experienced a hot burn.

The study site and recording methods

During 1987 while making cursory assessments of mygalomorph occurrences in Durokoppin and East Yorkrakine reserves, a population of *I. nigrum* which appeared to be viable with a range of burrow sizes (representing different age classes, Main 1978) was located near the northern edge of EYR. Twenty-eight burrow entrances were pegged, measured and arbitrarily aged. In May 1989 a 25 m x 53 m plot was pegged to embrace several clusters of burrows. The experimental burn of March 1991 extended to within 5 m along the western boundary of the study plot and 15 m to the southwest of the southern boundary.

The study plot (Fig. 3) is aligned north south and is sited just over 600 m from the western boundary of EYR. It is in a patch of mallee/woodland with an open understory. The plot comprises eight larger trees (butt circumference at about 1.5 m height ranging from 78 to 210 cm): *Eucalyptus salmonophloia* Mueller (three trees, of which two were partly dead in 1988), *E. capillosa* Brooker and Hopper (four, of which one was represented by butt and fallen boughs only) and one gimlet *E. salubris* Mueller. There are also five medium sized (butt circumference 50 cm – 60 cm) single stemmed eucalypts and eight small (butt circumference 21 cm – 38 cm), mostly multiple stemmed trees (predominantly *E. transcontinentalis* Maiden). The distribution of the trees with canopy cover (which also equates to litter cover area) is shown in Figure 3. Associated with the eucalypt trees there are small trees of *Santalum spicatum* (R. Brown) and *Exocarpus*, several species of *Acacia* shrubs, prostrate *Enchylaena*, *Suaeda* and *Rhagodia* shrubs (the latter three plants all have some tolerance to early salinisation), and a few *Stipa* tussocks, *Olearia* and myrtaceous shrubs. Ephemeral Compositae are prevalent in the late winter and spring.

Bare ground with scattered sparse litter occurs irregularly between the fringes of permanent litter. Spider burrows are sited mostly in the permanent litter, with a few amongst scattered litter. Prey for the spiders probably consist predominantly of ants (*Myrmecia* and *Iridomyrmex purpureus* (Smith)), termites and various seasonal insects.

Censusing of spider burrows

By 1989 all observed burrows within the plot were pegged with 25 cm steel wire pegs with numbered tags. Each burrow entrance (door and lumen diameter) was measured with callipers. Three arbitrary age classes were allocated according to burrow entrance diameters as follows: emergents (with door/lumen up to 1.4/1.0 cm); juveniles (with door/lumen between 1.5/1.1 cm and 2.0/1.4 cm) and adults (with door/lumen diameters greater than 2.1/1.5 cm). Adult assessment was based on the minimal burrow entrance dimensions observed elsewhere for brooding adult females (Main 1957 and data in author's collection). Emergents are spiderlings which have established burrows in the autumn/winter of a given year. Juveniles are all spiders post year of emergence and smaller than estimated adult size. From 1989 onwards all observed burrows within the demarcated plot were tagged, censused and measured once to three times a year when opportunity availed including an annual spring (September or October) census for each year except 1991 (last census 30 July) and 1994 (last census 30 May). No further burrows were tagged after the census of 1994 and no census was conducted in the years 1995 and 1996. Previously tagged burrows were monitored in 1997, 1998 and 1999.

Unknown aspects of the biology of the spiders which would affect the demography in the study plot include: (a) number of females reproducing each year; (b) number of males maturing each year; (c) number of young a female produces; and (d) the distance emergents disperse. Some of the juvenile mortality (from larger burrows scored as defunct) may represent adult males. Earlier records (Main 1957) indicate at least 16 young are produced by a female but egg numbers are needed for an accurate figure on fecundity. Emergents tend to aggregate around a female's burrow and further dispersion (which would be hazardous due to possible predation) is presumably prompted by unavailability of space amongst other burrows.

Results And Discussion

Between 1987 and October 1993, 154 burrows were tagged (burrows of 1994 emergents were counted but not tagged). Although monitoring of marked burrows began in 1988, it was not until 1989 that all burrows observed within the study plot were tagged and formal censusing of the demarcated population dates from that year and continued until 1994. Main (1992) gave a preliminary account on the population for the years up to 1991. The graph in Figure 4 indicates a progressive decline for all age groups but with some recovery in 1992 and again in 1994 for adults. Some of the adults represent survival from the eleven burrows marked as adults in 1987 (five persisting in 1992 and two persisting in 1994; two burrows became defunct over the 1993/94 summer). The two surviving spiders (tags #8 and #25) suggest that once female spiders mature to adulthood they may persist for at least another seven years. In fact these two spiders were still extant in 1999 implying survival for at least 12 years post maturity. It appears the minimal age to maturity is probably five or six years: an emergent marked in 1987 (tag #7) matured by the end of 1991. No spiders which emerged in 1989 attained maturity; the burrows became defunct either in the first year or while the spiders were still juveniles.

Figure 5 gives the number of spider burrows and relative proportion for each age class of the total population for the years 1989 to 1994 inclusive. Emergents appear to be the age group most at risk; they show a drop in numbers from the first census of 20 spiders with a decline to ten and five spiders in the last two years. The 1994 census was made on 30 May and although it is possible that some 'stragglers' may have emerged later this is unlikely since there had already been good break of season rains. Total numbers for the population declined from 65 in 1989 to 43 in 1994 (with a drop to 41 in 1991). Although there were fluctuations in population size in the different years, less than 80% of the total number of burrows found in the first year of the census were scored in later years. Of the burrows tagged between 1987 and 1993 only five, three and three survived to the years 1997, 1998 and 1999 respectively. A cursory search of the site revealed nine unpegged burrows in 1998 and seven in 1999 indicating at least some continuing recruitment.

Table 1 shows the percentage of mortality within each age group and the total population in the years

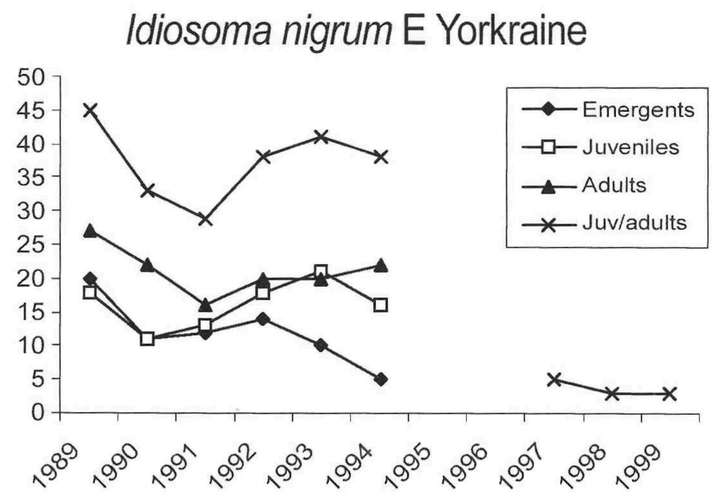

FIGURE 4. *Idiosoma nigrum* population at East Yorkrakine Nature Reserve showing fluctuations in numbers of respective age groups: emergents, juveniles, adults, and adults and juveniles combined for years 1989 to 1994; juveniles and adults combined from burrows tagged prior to 1994 for the years 1997, 1998 and 1999.

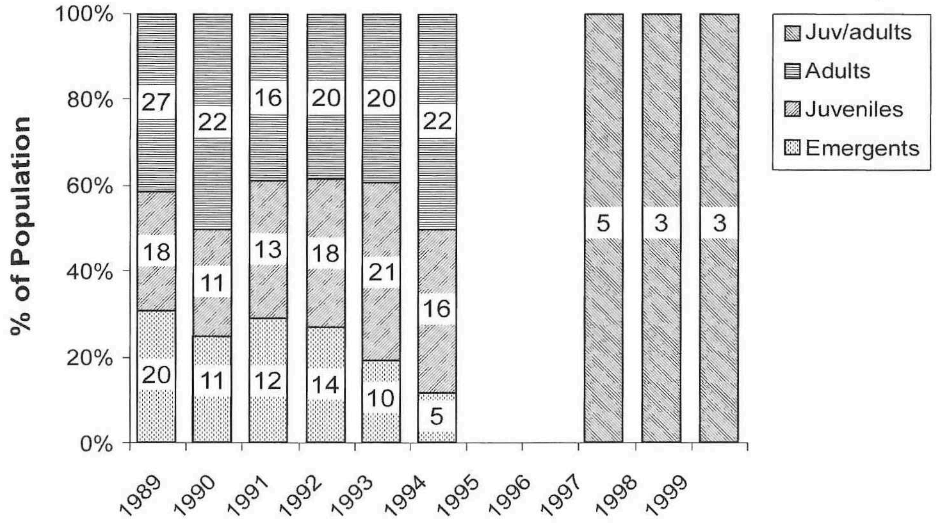

FIGURE 5. *Idiosoma nigrum* population at East Yorkrakine Nature Reserve showing proportion of total population and actual numbers of burrows of each age group for years 1989 to 1994. For years 1997, 1998 and 1999 only juveniles and adults tagged prior to 1994 are included.

1989 to 1994. Mortality was assessed as the year in which a burrow was recorded as defunct. Except for the years from 1991 to 1992, when juveniles demonstrated a very high mortality rate, emergents consistently exhibited the highest mortality rate of the three age classes.

Deterioration of habitat

In 1992 and 1993 a marked deterioration in the habitat was noted, particularly in the moribund state of vegetation such as acacia shrubs and prostrate vegetation including *Enchylaena.* This trend continued until in 1997 all myrtaceous shrubs were noted as dead and in 1998 it was observed that all acacias and *Exocarpus* were dead or dying, while some quondongs (*Santalum spicatum* – a parasitic species) persisted. Some invasion of exotics was noticed in 1998, eg freesias along the western edge of the study site near the area affected by the 1991 burn.

TABLE 1. Percentage mortality of all spiders and adults, juveniles and emergents for years 1989 to 1994 inclusive.

	Total	Adults	Juveniles	Emergents
1989/90	49.23	33.33	33.33	85.00
1990/91	46.00	36.36	36.36	64.70
1991/92	30.76	18.75	76.92	25.00
1992/93	44.44	25.00	38.88	57.14
1993/94	31.36	20.00	33.33	50.00

Grazing pressure associated with increased kangaroo activity observed in 1992 possibly added to the lack of seedling regeneration caused by rabbits in earlier years. Mouse holes were also numerous in 1992 and any seed bank was possibly reduced by mice. The canopy cover provided by the taller eucalypts was reduced through the pruning actions of large flocks of roosting galahs. This resulted in reduced shade (exacerbating summer ground temperatures) and obstructed burrow entrances with foliage, thereby interfering with foraging by the spiders.

General deterioration of the perennial vegetation possibly also reduced insect visitations to the site (including ants – staple diet of trapdoor spiders). Insect activity appeared to become concentrated in the spring when the Compositae attracted a range of flying insects as well as ants.

Prognosis

As noted earlier there is a general gradient in the fall of the land from the cleared sand ridge to the south of the East Yorkrakine reserve to the cleared land on the northern boundary which is already suffering from salinisation. Prior to the fire of 1991 the study site was protected from encroaching salinity by the buffer of shrub/heath vegetation upslope. Although water tables in bushland of the region are reported to be 7 m lower than surrounding cleared land (as at Durokoppin Nature Reserve) these other sites are higher in the landscape than the upslope to the south of EYR. Furthermore the water table, even in the middle of Durokoppin and Kodj Kodjin (31°27'S, 117°47'E) reserves, is reported to be rising (George et al. 1996; Salama & Bartle 1995). In addition, the northern edge of EYR lies closer to a valley floor.

The effect of the 1991 fire would be comparable to clearing in that the taller vegetation (acacias and sheoaks) was killed, thus losing a mechanism for keeping the water table down. Downslope flow of water would have increased and exacerbated the invasion of salt from the valley. Much of the vegetation decline in the study site (at the lowest elevation in the reserve) could be attributable to the 1991 fire even though short-term regeneration was apparent. A postulated consequence of the deteriorating vegetation and repercussions (including reduced shade from high canopy, shelter from lower shrubs and increased ground temperatures and less variety in prey) is the decline in the *Idiosoma* population.

Hester and Hobbs (1992) interpreted that fire could be 'a viable management option' for weed invasion along the edges of 'small remnant areas where other types of disturbance are absent'. They did not, however, take into account (or foresee) possible changes in the hydrology resulting from fire as *de facto* clearing nor how such changes might affect other components of the biological community. Furthermore, Main (1992) concluded that 'where *Idiosoma* is now present in remnants it is likely to persist provided there is minimal disturbance of the habitat and the habitat is protected from fire'.

Conservation

Idiosoma nigrum shows some morphological variation, particularly regarding degree of sclerotisation of the abdominal cuticle and to some degree enlargement of the eyes, over its geographic range. The accentuation of these traits appears to be clinal in a south to north and west to east direction (pers. observ.) which suggests adaptation to aridity on the margins of the species distribution. It thus becomes important to conserve the species over its entire range. The populations in the central wheatbelt as well as being fragmented appear to be the most vulnerable because of the general impact of widespread salinisation and other factors of habitat degradation. To conserve the species in this broad area of its geographic range our best hope is to locate populations on topographically high, little disturbed remnants and to protect such habitats from fire. One such population has recently been located in ungrazed remnant bush on private property along the ridge east of Yorkrakine Rock Nature Reserve (31°26'S, 117°31'E). This gives hope for persistence of the species in this part of the central wheatbelt.

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