Seasonal abundance and diversity of soil fauna in the principal cotton growing valleys of NSW

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SUMMARY

This study is a baseline biodiversity survey of the principal soil faunal groups found in irrigated cotton fields of north western New South Wales. Field work was conducted on commercial cotton farms located in the Macquarie, lower Namoi, and Gwydir valleys. The various growers and agronomists involved were practitioners of innovative and 'best management' practices. Detailed information pertaining to soil properties, cropping history, and calendar of operations were collated for all fields. Fields sampled differed in (i) the age of cotton production and (ii) the crop protection practices used to control insect pests.

Specific objectives of this project were: (1) to characterise and compare the relative abundance and species diversity of dominant ecological groups of soil meso–and macrofauna in irrigated cotton fields and their respective adjoining remnant sites; (2) to monitor short–term seasonal dynamics of these soil surface–active and in–situ invertebrate populations during the different phenological phases of the cotton crop; and (3) to devise a sampling protocol that is both repeatable and feasible.

Field experiments were conducted at three broad scales of agricultural realism. Some field experiments were conducted using whole cotton fields that were unreplicated, whilst others used large replicated plots within whole fields on commercial cotton farms. At the Australian Cotton Research Institute (ACRI), a small field with replicate plots of Envirofeast® cotton and lucerne was also sampled. Standardised experimental designs were devised and sampling equipment constructed. Surface–active species were collected using pitfall traps, ground searching, and an insect pooter. Pitfall trapping periods were usually aligned with irrigation cycles. Extensive field observations were completed to better understand species–specific behavioural patterns, identify key refugia used by soil fauna, and to collect species that might avoid pitfall traps. Soil cores were used to sample soil fauna in rhizosphere soil to a depth of 150 mm. Soil temperature readings and estimates of soil moisture content were taken at depths of 50, 100, and 150 mm.

Springtails, soil–dwelling beetles, ants, and earwigs were considered in detail, and identified to species or morpho–species. Beetles and earwigs were assigned 'reported' feeding habits, and ants and springtails allocated to functional groups. A total of 196 species were identified from these groups. Within the groups, seasonal catches in individual fields were dominated by one to three species, giving a total of about 20 species that were consistently common on the soil surface. Crickets were the most common soil fauna of an additional 14 identified species. Four species and one genera of springtails were recorded for the first time in Australia. Larvae of the Green Carab Beetle, *Calosoma schayeri*, was also collected for the first time in Australian field crops. Very little is known about the biology and ecology of almost all soil fauna species identified in this study.

Generalist predators and litter transformers were the dominant ecological groups found on the soil surface. Among the predators, earwigs, beetles (carabids and staphylinids), and wolf spiders were generally nocturnal. For the soil–dwelling beetles, the most common feeding habit groups were generalist predators, fungivores and scavengers. For springtails and ants, the most commonly represented functional group(s) were hemiedaphic (i.e. fauna that move between the soil surface and upper 150 mm of the soil profile) fungal feeders; and generalised myrmicines (*Pheidole* spp.), dominant dolicherines (*Iridomyrmex vicinus* spp. group), and opportunists (*Rhytidoponera metallica* group), respectively. Native (large, deep burrowing species) and introduced earthworms, and Meat Ants were entirely absent from the commercial cotton fields sampled during this study.

Irrigation and effective rain was a primary factor influencing seasonal daily catch rates (DCR's) of surface–active springtails, with the highest DCR's coinciding with the application of irrigation water or following effective rain. For example, the highest DCR's of surface–active springtails coincided with irrigations or effective rain. Surface soil moisture was also important for earwigs, but DCR's were often smaller during trapping periods that included, or closely followed, the application of irrigation water. DCR's of total earwigs peaked during January, and peaks and troughs appeared to correspond well with average air temperatures. However, significant declines in DCR's of ants followed heavy rains and/or excessive waterlogging. The opportunist ant species, *R. metallica*, was particularly sensitive to waterlogging. Foraging activities of *I. vicinus* group workers ceased when the application of irrigation water coincided with larvae being present in their nests.

Several farm management factors had an impact on species diversity and relative abundance of soil fauna; including the age, size, tillage regime, and rotation sequence of each cotton field; availability of surface residues and food; and management tactics used to control insect pests. Soil cracks and crevices were the most important within–field refugia for soil–dwelling beetles and earwigs. Lucerne strips in Envirofeast® cotton at ACRI appeared to benefit some predatory ants, spiders, springtails and crickets, but were poorly colonised by predatory soil–dwelling beetles and earwigs. In addition to soil water potential, springtail numbers appeared to be affected by the availability of moistened surface residues, soil predator numbers, and insecticide usage. For example, seasonal DCR's of springtails were small in Envirofeast® cotton that had the largest DCR's of ants and earwigs across all cotton fields sampled. Springtails therefore appeared food limited, and might serve as an important food source for soil predators during stages I and II. Conversely, springtail DCR's across all seasons peaked in sprayed fields with long cotton histories and low soil predator numbers. Sprayed and unsprayed fields, both large and small, with long histories of irrigated cotton, generally supported smaller total numbers of soil–dwelling beetle species. Unsprayed, Ist–season cotton had the greatest species diversity of soil–dwelling beetles, whilst all individual cotton fields were dominated by species with body lengths < 5 mm.

Most predatory species did not colonise irrigated cotton until stage II in sprayed fields, and stages II and/or III in unsprayed areas.

Furrow–irrigated cotton fields with large DCR's of ants during stage I were: (1) well drained, (2) usually small in size, (3) often linked to grassy field margins or lucerne strips, (4) maintained with minimum tillage, and (5) managed without soil and foliar insecticides or only 'soft option' foliar sprays. The smallest DCR's and lowest species diversity of ants were collected in large fields that either (i) had long histories of conventionally sprayed cotton or (ii) were excessively waterlogged.

The Common Brown Earwig was more abundant during stages I and II in old fields than in newly developed ones. *Labidura truncata* appeared (1) less affected by field size, insecticide usage, rotation sequence, and tillage than springtails, ants and ground beetles; and (2) tolerant to even the most extreme cotton management practices. Large numbers of earwigs in old cotton fields during stage I, relative to other predatory soil fauna, is indicative of a cumulative effect.

Insecticide usage is a key management factor influencing species diversity and abundance of non–target invertebrates like soil fauna in cotton agroecosystems. Repeated endosulfan sprays appeared to cause no detectable reduction in DCR's of several groups of soil fauna at Doreen during stages I and II of 1995–96. Consistent treatment differences for springtails, soil–dwelling beetles, and ants in sprayed and unsprayed cotton were generally confined to stage III. Predatory beetles and ants appeared to be the most adversely affected by stage III insecticides. Most groups of springtails, soil–dwelling beetles, and ants did not recover, either between consecutive pyrethroid, carbamate, and organophosphate sprays, or by the final sampling. During stage III, the Green Carab Beetle, *C. schayeri,* comprised 45% of the generalist predators collected in unsprayed, Ist–season cotton; but was entirely absent in sprayed cotton, irrespective of age. The practice of simultaneously treating several large fields on individual cotton farms with broad spectrum insecticides presents major problems for most non–target invertebrates like the soil fauna.

This project provides a foundation on which to investigate the function and/or potential contribution of key ecological groups of soil fauna in the cotton agroecosystem. The potential benefits of more effective husbandry of the soil biota are discussed, together with future research needed for beneficial soil fauna to be more effectively utilised in IPM systems.