THE FOSSIL INSECTS OF AUSTRALIA

P.A. JELL

Jell, P.A. 2004 16 08: The fossil insects of Australia. *Memoirs of the Queensland Museum* **50**(1): 1-124. Brisbane. ISSN0079-8835.

A taxonomic catalogue of the known fossil insects of Australia provides illustrations of at least one species of every genus so far identified. Every known species is recorded with the age, rock unit (formation) and location (sedimentary basin). Some synonymies and updated taxonomic placements are included but this has not been an exhaustive review of taxonomy. The principal sources for fossil insects are described as the Upper Permian Boolaroo Formation in the Newcastle Coal Measures adjacent to Lake Macquarie, the Hawkesbury Sandstone at Brookvale in Sydney, the Mt Crosby and Blackstone Formations in the Upper Triassic Ipswich Coal Measures of southeastern Queensland and the Lower Cretaceous Koonwarra Fossil Bed in South Gippsland, Victoria. Other minor sites are discussed and potential for further research is outlined. *Austroscarites* is introduced to replace the preoccupied *Scarites* Hamilton not Fabricius. ❐ *Fossil insects, Australia, Permian, Triassic, Cretaceous, catalogue.*

Peter A. Jell, Queensland Museum, PO Box 3300, South Brisbane, Queensland 4101, Australia; *1 August 2004.*

The living insect fauna of Australia is obviously abundant and diverse to inhabitants and visitors alike. The importance of the insect fauna to our way of life and our economy has been documented by many people since the first arrival of Europeans. Assuming living diversity is an indication of the insect fauna at any instant of the geological past and in view of the known evolution of insects during geological time we can project an enormous number of species that must have inhabited this continent since the origin of insects during the early Palaeozoic. However, the majority of these were almost certainly never fossilised and have left no record. Marine faunas have a better fossilization potential than terrestrial ones. It is estimated that overall less than 1% of living species at any one instant in time will be fossilized and collectable to enter the palaeontological literature. Thus the known fossil insect record of more than 400 species in approximately 250 genera is only a small fraction of the insect species that have lived in Australia.

In each edition of 'The Insects of Australia' a chapter was devoted to their fossil history. Riek (1970c) and Kukalova-Peck (1991) gave good overviews of the fossil history of Australia and fitted it into the broader story of insect evolution across the globe. The aim of this publication is to complement those accounts with a comprehensive listing of the fossil insect species described from Australia along with illustration of at least one species from each genus.

GEOLOGICAL SETTING OF FOSSIL INSECT SITES

Compared to the number of Australian fossil sites or to the number of insect fossil sites worldwide only a few sites around Australia have yielded fossils of insects (Fig. 1). These sites provide imperfect data for only a very few instants of geological history (Fig. 2).

HELLYER GORGE SITE IN UPPER CARBONIFEROUS WYNYARD TILLITE.

The earliest known insect from Australia comes from the Hellyer Gorge district of northwestern Tasmania where the single, almost complete specimen, with 50mm wing span, was found in a 1m fossiliferous band of varve-like sediments within the Wynyard Tillite. Tillites occur in the formation both above and below the finegrained fossiliferous section. The co-occurring fossil plant, *Botrychiopsis plantiana*, and Stage 1 microflora indicate a Late Carboniferous age and the primitive insect structure suggests early Late Carboniferous. The sedimentary environment and paucity of associated insects indicate deposition in cold conditions close to glacial ice. Riek (1976) erected the Psychroptilidae and Suborder Neosecoptera as monotypic taxa for this insect, *Psychroptilus burrettae* Riek, 1976 within the Order Megasecoptera. He outlined the difficulty of classifying this species by indicating features it shares with the Megasecoptera (wing venation except Sc ends abruptly on the costal margin just beyond the midlength of the wing) others it shares with the Palaeodictyoptera (wings

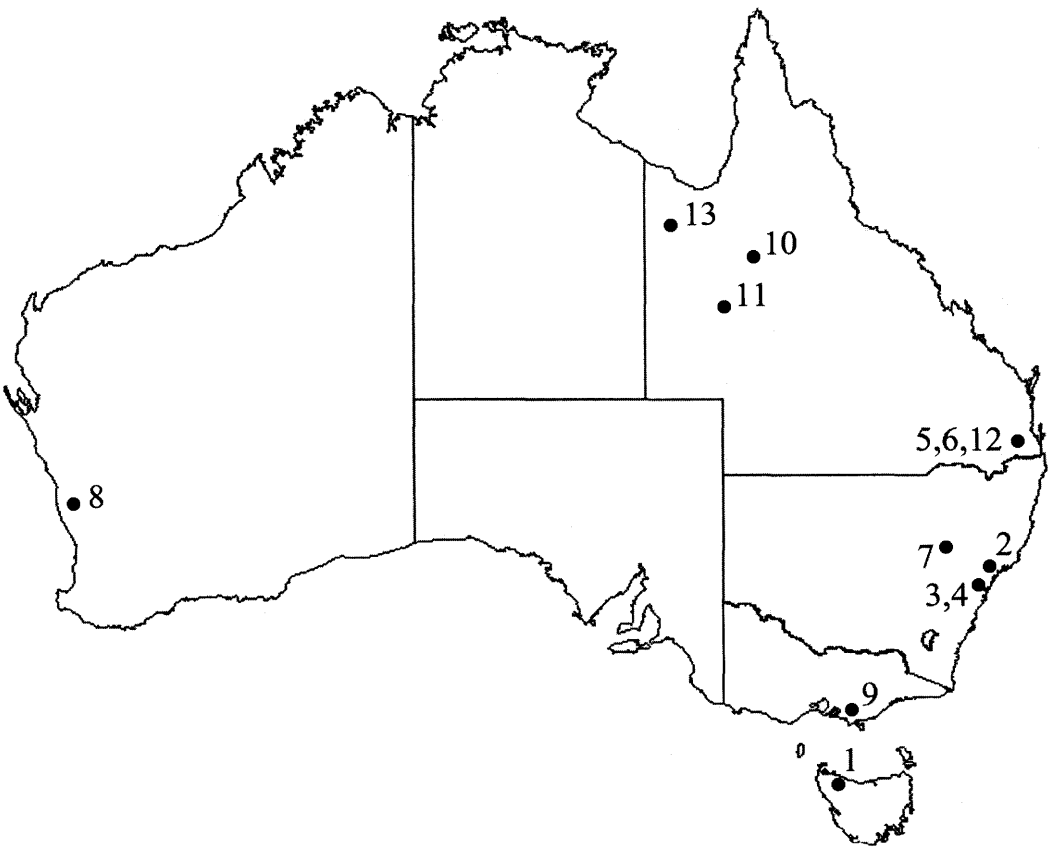


FIG. 1. Distribution of main fossil insect sites. 1=UCarboniferous Wynyard Tillite at Hellyer Gorge; 2=UPermian Newcastle Coal Measures at Belmont just south of Newcastle; 3=MTriassic (Anisian) Brookvale Shale in Hawkesbury Sandstone near Manly in suburbs of Sydney; 4=MTriassic (Anisian) Ashfield Formation in Wianamatta Group at St Peters near Newtown, suburban Sydney; 5=UTriassic (Carnian) Mt Crosby Formation in lower Ipswich Coal Measures just north of Ipswich; 6=UTriassic (Carnian) Blackstone Formation at top of Ipswich Coal Measures on Denmark Hill in suburban Ipswich; 7=LJurassic Talbragar Fish Bed in the Purlawaugh Formation near Gulgong; 8=LCretaceous Cockleshell Gully Formation in Hill River area, northern Perth Basin; 9=LCretaceous (Aptian) Koonwarra Fossil Bed on the South Gippsland Highway near Tarwin in the Gippsland Basin; 10=LCretaceous Wallumbilla Fm near Richmond, Great Artesian Basin; 11=UCretaceous Winton Formation near Winton, Great Artesian Basin; 12=Palaeocene Redbank Plains Formation east of Ipswich; 13=Late Oligocene/Early Miocene Upper Site in Riversleigh Limestones north of Mount Isa.

broad at the base) and others not previously known in either of those orders. By comparison to the Northern Hemisphere faunas the Carboniferous insect fauna of Australia is virtually unknown.

BELMONT INSECT FAUNA IN UPPER PERMIAN NEWCASTLE COAL MEASURES. The Upper Permian insects from the Newcastle Coal Measures described mainly by Tillyard came from an area of 10-20km^2 between the town of Belmont and Warners Bay on the eastern side of Lake Macquarie some 10km southwest of Newcastle. A sand and conglomerate fan was probably braiding through coal swamps along the southeastern flank of the Hunter Trough in the Late Permian, sourcing its clastic material primarily from higher land to the north and northwest (Engel, 1966). The widespread and persistent insect beds, which are fine grained volcaniclastic units (tuffs) associated with plenty of plant detritus mainly *Glossopteris* leaves and *Phyllotheca*, were apparently deposited during a brief, episodic event and fairly rapidly buried.

The insects were very likely a wing-float concentration, with the wings remaining buoyant until the waterbody was choked with ash, possibly enhanced by storm action during or just after the eruption. Adjacent coal seams, conglomerates and tuff beds indicate a dynamic environment with swamp conditions prevailing when and where short term quiet conditions became established. Details of stratigraphic relationships in the Belmont area are provided by Hawley & Brunton (1995) and Little et al. (1996). Rare insects have been found in the Lambton Formation adjacent to the Dudley Coal Seam (*Permoscarta mitchelli* Tillyard, 1918b, *Mitchelloneura permiana* Tillyard, 1921b and *Lophioneura ustulata* Tillyard, 1921b) at the base of the Newcastle Coal Measures but the major horizon is within the Boolaroo Formation in the upper half of the coal measures. As with many coal measure stratigraphies there is an extremely fine subdivision to reflect the various coal seams but these units are often of restricted extent so the listing below refers to the Newcastle Coal Measures as the provenance of the insects from this area. This fauna is rich in Homoptera, Psocoptera, Neuroptera, Mecoptera but lacks blattoids or palaeoptera.

MIDDLE TRIASSIC HAWKESBURY SANDSTONE AT BROOKVALE, SYDNEY. The Middle Triassic (Anisian) Hawkesbury Sandstone in the Sydney Basin envelops a lens of fine mudstone referred to as the Brookvale Shale lens (about 8m thick) which was best exposed in the Brookvale Quarry on Beacon Hill, Brookvale, near Manly, north of Sydney Harbour where it yielded many fish, many plants (*Dicroidium zuberi* flora), amphibians, unionid bivalves, crustaceans, insects, trace fossils and some enigmatic fossils. This mudstone lens may be interpreted as a lacustrine interval on a quartz sandstone coastal plain and from the fauna a freshwater environment is most probable. The insect fauna includes the large titanopteran, *Clatrotitan,* a mecopteroid, a protorthopteroid, orthopteroids and a stonefly.

MIDDLE TRIASSIC ASHFIELD FORMATION AT ST PETERS, SYDNEY. The Ashfield Shale (40-60m thick in the Wianamatta Group) overlies the Mittagong Formation (up to 15m thick) which in turn overlies the Hawkesbury Sandstone in the area immediately west and southwest of Sydney known as the Cumberland Basin. Outcrop of the Ashfield Shale defines the shape of the basin. Siltstone and

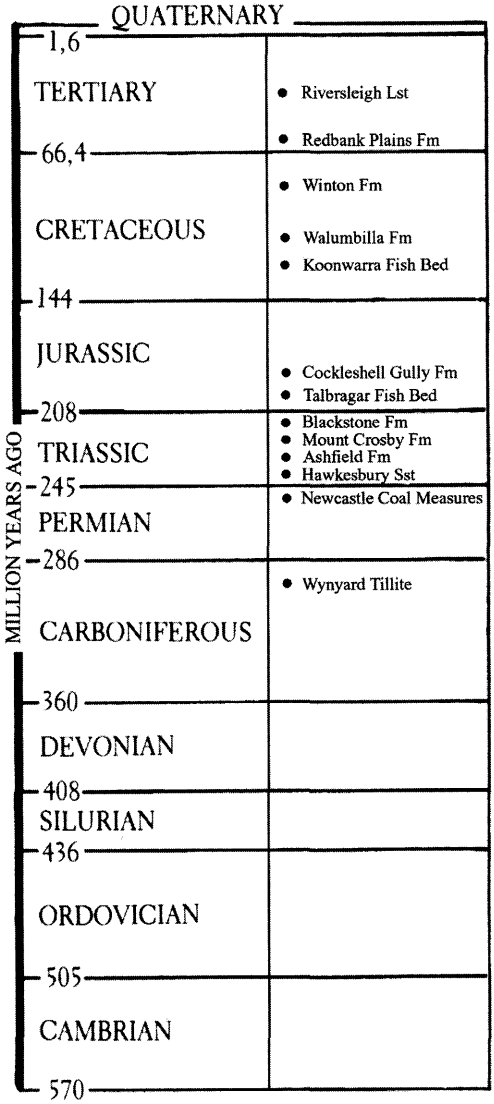


FIG. 2. Stratigraphic succession of important known insect sites.

clay from low in the formation was extensively quarried in the St Peters district for manufacture of house bricks. An extensive fauna of bivalves, fish, a shark, labyrinthodonts, an isopod, the insects and plants has been collected from these quarries and indicates a freshwater environment. Its age is Middle Triassic (late Anisian) based mainly on the floral components of the fauna. The insects are predominantly beetle elytra, a large blattodea and the large titanopteran, *Mesotitan*,

but nothing has been added to the work of Tillyard (1916). Tillyard (1918b) described another Ashfield insect fauna from a railway cutting at Glenlee, 6.5km south of Campbelltown on the main southern line with a very similar assemblage to that from St Peters i.e. dominated by beetle elytra, the same blattodean genus and a mecopteroid rather than the large titanoptera.

UPPER TRIASSIC MT CROSBY FORMATION, IPSWICH COAL MEASURES AT MT CROSBY, NORTH OF IPSWICH, SOUTHEASTERN QUEENSLAND. The Mount Crosby Formation, the oldest in the Ipswich Coal Measures occupies an area north of Ipswich adjacent to the Brisbane River of some 30km^2. It is 20-30m thick and consists mainly of polymictic, poorly sorted conglomerate but has 3 shale units, up to 6m thick near the bottom, middle and top of the unit. The upper two shale units are fossiliferous with prolific plant and insect remains. The conglomerates of the formation indicate rapid erosion from an adjacent highland (the Daguilar Block) and little transport. The shale units indicate restricted quiet lacustrine conditions at various times on this piedmont fan. The insect fauna is dominated by Blattodea and Homoptera with Mecoptera, Diptera, Orthoptera, Neuroptera, Coleoptera, Odonata, Plecoptera, and Hymenoptera represented.

UPPER TRIASSIC BLACKSTONE FORMATION, IPSWICH COAL MEASURES AT DENMARK HILL, IPSWICH, SOUTHEASTERN QUEENSLAND. At Denmark Hill very close to the centre of Ipswich the upper part of the Ipswich Coal Measures underlies an urban park reserve. In 1890 insects were first found in this locality and much geological interest followed. The richly fossiliferous horizon is a finely arenaceous siltstone about 15cm thick assigned to the Blackstone Formation, the youngest formation of the Ipswich Coal Measures. Coal seams are known above and below the fossiliferous sequence indicating a lacustrine environment. Plant fossils are prolific and among the fauna freshwater bivalves and estherid crustaceans accompany the insects while dinosaur footprints are known in the formation. Dunstan (1916) gave a detailed account of the small quarry in which the insects were collected. The fauna is dominated by beetle elytra, Blattodea and Homoptera and includes fewer Orthoptera, Phasmatodea, Neuroptera, and Mecoptera.

LOWER CRETACEOUS (APTIAN) KOONWARRA FOSSIL BED NEAR LEONGATHA, SOUTH GIPPSLAND, VICTORIA. During road widening excavations on the South Gippsland Highway between Koonwarra and Tarwin council workers recognised fossil fish in the spoil. A short succession of varved lake deposits is within a thick fluviatile succession, the Korumburra Group (=Strzelecki Group). The lacustrine sequence contains some beds with abundant fish (Waldman, 1971) and other beds with numerous insects, plants and a few other arthropods, some annelid worms (Jell & Roberts, 1986) and a few feathers (Talent et al., 1966), the earliest indications of birds in Australia. The insects include many aquatic larvae and numerous terrestrial adults. By analogy with present day lakes in western Victoria it was possible to identify representatives of the insect fauna that lived in the lake, a fauna of larvae that lived in a feeder stream and insects that lived on the surrounding land and then fell onto the surface of the water (Jell & Duncan, 1986). Mayfly nymphs from the stream fauna and dipteran and beetle larvae from the lake dominate the aquatic fauna while Hemiptera, Mecoptera, hymenopterans, beetles, flies and blattodea are common among the winged adults. The beds are dated palynologically (Dettmann, 1986) as Aptian and a fission track date (Drinnan & Chambers, 1986) of 116±5Ma has been obtained.

PALEOCENE REDBANK PLAINS FORMATION NEAR IPSWICH, SOUTHEASTERN QUEENSLAND. The Tertiary Booval Basin which overlies the Mesozoic Ipswich Basin extends over 50km^2 in the Ipswich-Bundamba-Dinmore area. The Palaeocene Redbank Plains Formation consists of about 70m of mudstone, claystone, shale and fine sandstone which were deposited in a freshwater lake in structural depressions on the eroding upper surface of the Ipswich Basin sediments. The fossil content includes fish, turtles, crocodiles, ostracodes, cladocerans, insects and plants. Riek (1952a) noted two different faunas: one at Redbank Plains in a hardened band of ferruginous mudstone is dominated by Homoptera and Coleoptera with a few Diptera, Mecoptera, Neuroptera, Orthoptera and Hemiptera and the other, at Dinmore in compact clays and clay shales, contains Orthoptera, Isoptera, Megaloptera, Homoptera and possibly Odonata.

Order EPHEMEROPTERA (mayflies)

Family **BAETIDAE** Leach, 1815

Cleon Leach, 1815
Larva: small, shrimp-like; head very small; cerci short.
emmavillensis Riek, 1954b; Pliocene; Vegetable Ck, Emmaville, NSW.

Cleon emmavillensis, AMD115, x5

Family **LEPTOPHLEBIIDAE** Banks, 1900

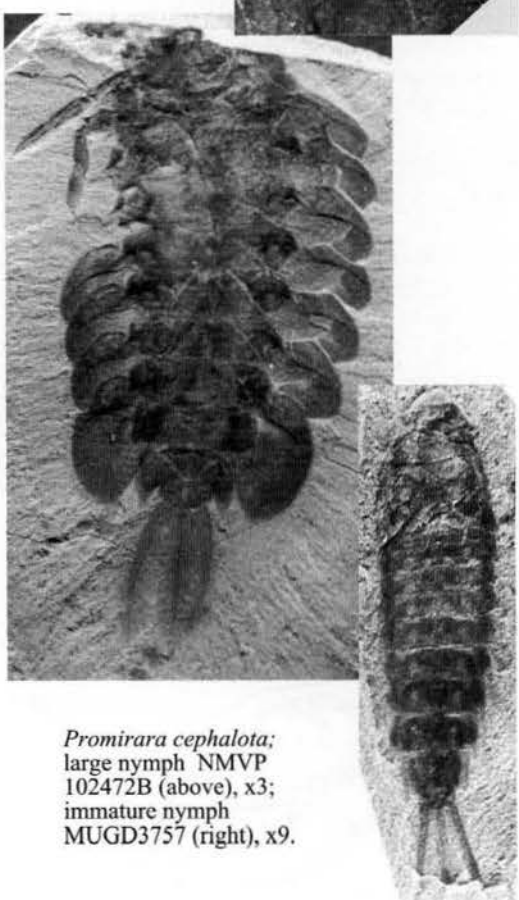
Atalophlebia Eaton, 1881 [*Ephemera australis* Walker, 1853]
Nymph dorsoventrally depressed, with widely flattened femora; head rectangular; eyes small, posterolateral, protruding slightly at margin, well separated medially; thorax slightly wider than head; insertions of foreleg close together, of mid and hindlegs well apart; femora 3 times as long as wide; tibiae not strongly flattened, not quite as long as femora; abdominal segments gradually increasing in length but narrowing, with 9th segment as long as wide; caudal cerci as long as abdomen.
culleni (Etheridge & Olliff, 1890); Plio; Vegetable Ck; Emmaville, N.S.W.

Atalophlebia culleni, AMD113, x5

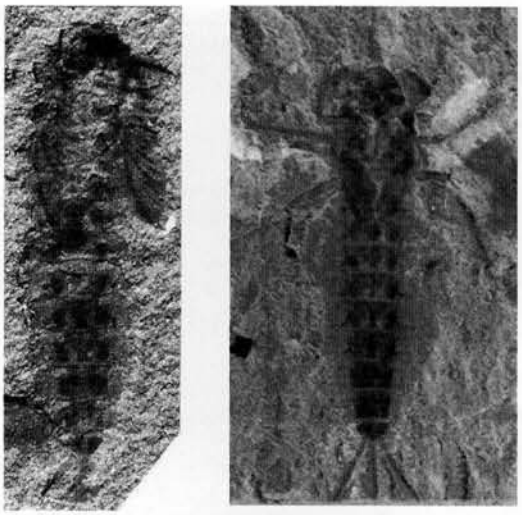
Family **SIPHLONURIDAE** Banks, 1900

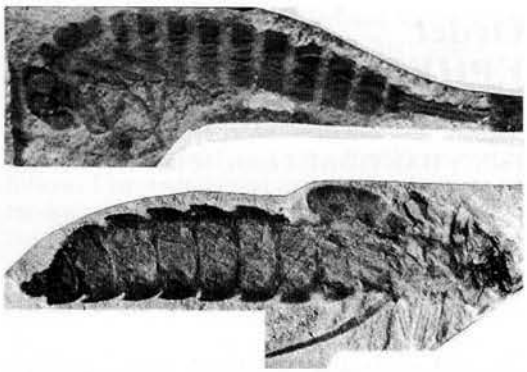
Promirara Jell & Duncan, 1986 [*cephalota*]
Nymph only. Similar to living *Mirawara* but with mouthparts less highly adapted for predation. Abdomen with 7 pairs of subequal gills, first pair not reduced. Cerci with hairs on the lateral as well as the median margin but hairs on lateral margins shorter and not extending to the base of cercus.
cephalota Jell & Duncan, 1986; LCret; Koonwarra FB; Gippsland.

Australurus Jell & Duncan, 1986 [*plexus*]
Nymph only. Head elongate; mandibles large; antenna long; face above antennal insertions ridged. Legs long, thin; tibia shorter than tarsus; tarsal claw apparently long. Mesonotum raised, produced caudally; pronotum large. Abdomen with 7 pairs of unmodified lamellar gills; gill structure imperfectly known but each gill with a strengthened longitudinal ridge at or close to fore margin, possibly with a fibrillar tuft at base; segments 1-9 strongly produced posterolaterally into spines. Caudal filaments with dense fringes of fine hairs except on outer margins of each lateral filament.
plexus Jell & Duncan, 1986; LCret; Koonwarra FB; Gippsland.



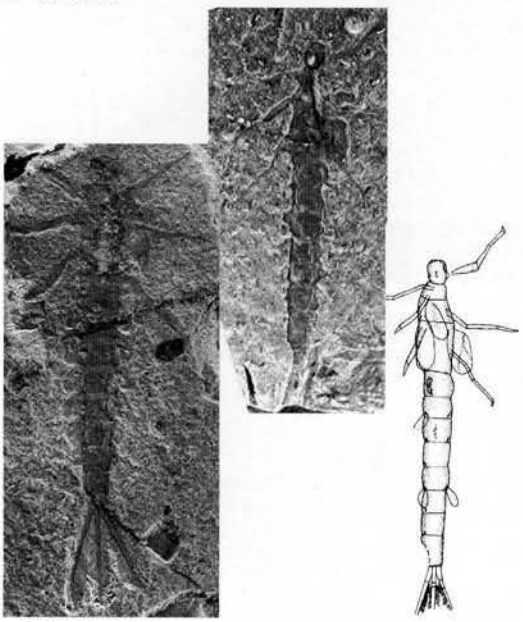
Promirara cephalota; large nymph NMVP 102472B (above), x3; immature nymph MUGD3757 (right), x9.





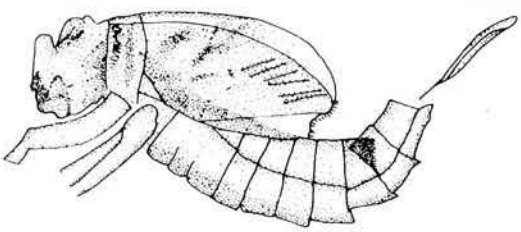
Australurus plexus; nymphs; MUGD3754 (far left), x8; NMVP102450 (left), x6; NMVP48610 (top, above), x8; NMVP103120 (above), x4.

Dulcimanna Jell & Duncan, 1986 [*sculptor*]
Nymph only, large, elongate body 10 times as long as wide. Head rounded, relatively small, with large bulging dorsal eyes, with entire margin on labrum. Legs with femora of approximately equal length from fore to hind legs, with tibiae and unsegmented tarsi becoming longer to hind leg, with strong curved relatively long tarsal claw. Abdomen with flat lobate gills on segments 1-7, with gently convex internal margins not spinose posterolaterally. Caudal filaments equal, with dense comb of fine long hairs along lateral margins exvcept on outer edges of cerci.
sculptor Jell & Duncan, 1986; LCret; Koonwarra FB; Gippsland.



Dulcimanna sculptor; NMVP102507 (above centre) and AMF66758 (above left); x3. Line drawing (above right) of Jell & Duncan, 1986, fig. 2H

Siphlonuridae gen. nov. Jell & Duncan, 1986
Nymph only. Head rounded; mouthparts conspicuous; eye small; pleural spines at least on segment 9. Caudal filaments moderately long, slightly more than half length of abdomen.
gen. et sp. nov. Jell & Duncan, 1986; LCret; Koonwarra FB; Gippsland.



Siphlonuridae gen. et sp. nov., NMVP103210, x6. Line drawing (left) of Jell & Duncan, 1986, fig. 2E.

ACKNOWLEDGEMENTS

I thank Andrew Ross and Phillip Crabb, Natural History Museum for providing photographs of specimens in the collection under their care, Bob Jones, Australian Museum for the loan of specimens, Robert Beattie for providing upto date information on the Belmont/Warners Bay fossil insect sites, Paul Avern and Sue Parfrey, Queensland Museum, for help with photography and Megan Lloyd, Queensland Museum, for help in obtaining difficult literature.

LITERATURE CITED

ANSORGE, J. 1996. Insekten aus dem oberen Lias von Grimmen (Vorpommern, Norddeutschland). Neue Paläontologische Abhandlungen 2: 1-132, pls 1-17.

ARCHER, M., GODTHELP, H., HAND, S.J. & MEGIRIAN, D. 1989. Fossil mammals of Riversleigh, northwestern Queensland: preliminary overview of biostratigraphy, correlation and environmental change. Australian Zoologist 25: 29-65.

ARCHER, M., GODTHELP, H. & HAND, S.J. 1991. Riversleigh: the story of animals in ancient rainforests of inland Australia. (Reed: Sydney). 264p.

BALME, B.E. 1964. The palynological record of Australian pre-Tertiary floras. Pp. 49-80. In Cranwell, L. (ed.) Ancient Pacific floras. (University of Hawaii Press:Honolulu).

BLAGODEROV, V.A. 1994. Dipterans (Mesosciophilidae) from the Lower Cretaceous of Transbaykal. Paleontological Journal 27(1A): 123-130.

BORKENT, A. 1997. Upper and Lower Cretaceous biting midges (Ceratopogonidae: Diptera) from Hungarian and Austrian amber and the Koonwarra Fossil Bed of Australia. Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie) 249: 1-10.

CARROLL, E.J. 1962. Mesozoic fossil insects from Koonwarra, South Gippsland, Victoria. Australian Journal of Science 25: 264-265.

CARPENTER, F. 1992. Superclass Hexapoda. Pp. 1-655. In Kaesler, R. (ed.) Treatise of Invertebrate Paleontology, Part R. Arthropoda 4. Volumes 3 & 4. (Geological Society of America & University of Kansas: Lawrence, Kansas).

DAVIS, C. 1942. Hemiptera and Copeognatha from the Upper Permian of New South Wales. Proceedings of the Linnean Society of New South Wales 67: 111-112.

1943. A new species of *Permithone* (Neuroptera Planipennia) from the Upper Permian of New South Wales. Proceedings of the Linnean Society of New South Wales 68: 11-12.

DETTMANN, M.E. 1986. Early Cretaceous palynoflora of subsurface strata correlative with the Koonwarra Fossil Bed, Victoria. Memoirs of the Association of Australasian Palaeontologists 3: 79-110.

DODDS, B. 1949. Mid-Triassic Blattoidea from the Mount Crosby Insect Bed. University of Queensland Papers, Department of Geology 3: 1-11.

DRINNAN, A.N. & CHAMBERS, C. 1986. Flora of the Lower Cretaceous Koonwarra Fossil Bed (Korumburra Group), South Gippsland, Victoria. Memoirs of the Association of Australasian Palaeontologists 3: 1-77.

DUNCAN, I.J., BRIGGS, D.E.G. & ARCHER, M. 1998. Three-dimensionally mineralized insects and millipedes from the Tertiary of Riversleigh, Queensland, Australia. Palaeontology 41: 835-851.

DUNCAN, I.J. & BRIGGS, D.E.G. 1996. Three-dimensionally preserved insects. Nature 381: 30-31.

DUNSTAN, B. 1916. Mesozoic and Tertiary insects of Queensland and New South Wales. Stratigraphical features.Geological Survey of Queensland Publication 253: 1-10, pls 8-9.

1923. Mesozoic insects of Queensland. Part 1. Introduction and Coleoptera. Geological Survey of Queensland Publication 273: 1-74, pls 1-7.

ENGEL, B.A. 1966. Explanatory notes on the Newcastle 1:250,000 Geological Sheet, SI 56-2. (Geological Survey of New South Wales: Sydney). 63p.

ETHERIDGE, R. Jr 1913, Palaeontological contributions to the geology of Western Australia 4. Geological Survey of Western Australia Bulletin 55: 1-34.

ETHERIDGE, R. Jr & OLLIFF, A.S. 1890. The Mesozoic and Tertiary insects of New South Wales. Memoirs of the Geological Survey of New South Wales, Palaeontology 7: 1-18, pls 1-2.

EVANS, J.W. 1943a. Two interesting Upper Permian Homoptera from New South Wales. Transactions of the Royal Society of South Australia 67: 7-9, pl. 1.

1943b. Upper Permian Homoptera from New South Wales. Records of the Australian Museum 21: 180-198.

1947. A new fossil homopteran from Kimble's Hill, Belmont (Upper Permian). Records of the Australian Museum 21: 431-432.

1950. A re-examination of an Upper Permian insect, *Paraknightia magnifica* Ev. Records of the Australian Museum 22: 246-250.

1956. Palaeozoic and Mesozoic Hemiptera (Insecta). Australian Journal of Zoology 4: 165-258.

1957. Some aspects of the morphology and interrelationships of extinct and recent Homoptera. Transactions of the Royal Entomological Society of London 109: 275-294.

1958. New Upper Permian Homoptera from the Belmont Beds (Homoptera: Insecta). Records of the Australian Museum 24: 109-114.

1961. Some Upper Triassic Hemiptera from Queensland. Memoirs of the Queensland Museum 14: 13-23.

1963. The systematic position of the Ipsvichiidae (Upper Triassic Hemiptera) and some new Upper Permian and Middle Triassic Hemiptera from Australia (Insecta). Journal of the Entomological Society of Queensland 2: 17-23, pl. 1.

EVANS, J.W. 1971. Some Upper Triassic Hemiptera from Mount Crosby, Queensland. Memoirs of the Queensland Museum 16: 145-152.

FLECK, G. & NEL, A. 2003. Revision of the Mesozoic family Aechnidiidae (Odonata: Anisoptera). Zoologica 153: 1-172.

FLEMING, P.J.G. 1966. Notes on Triassic fossils from the Mount Crosby Formation in the Parish of Chuwar. Queensland Government Mining Journal 63: 119-120.

FLETCHER, H.O. 1971. Catalogue of type specimens of fossils in the Australian Museum Sydney. Memoirs of the Australian Museum 13: 1-167.

GILL, E.D. 1955. Fossil insects, centipede and spider. Victorian Naturalist 72: 87-92.

HAMILTON, K.G.A. 1992. Lower Cretaceous Homoptera from the Koonwarra Fossil Bed in Australia, with a new superfamily and synopsis of Mesozoic Homoptera. Annals of the Entomological Society of America 85: 423-430.

HAWLEY, S.P. & BRUNTON, J.S. 1995. The Newcastle Coalfield. Notes to accompany rhe 1:100,000 Newcastle Coalfield regional geology map. Department of Mineral Resources, Geological Survey of New South Wales Report GS1995/256: 1-93.

HILL, D., PLAYFORD, G. & WOODS, J.T. 1965. Triassic fossils of Queensland. (Queensland Palaeontographical Society: Brisbane).

1968. Cretaceous fossils of Queensland. (Queensland Palaeontographical Society: Brisbane).

1970. Cainozoic fossils of Queensland. (Queensland Palaeontographical Society: Brisbane).

HOLLDOBLER, B. & WILSON, E.O. 1990. The ants. (Belknap Press: Cambridge).

JELL, P.A. 1993. Late Triassic homopterous nymph from Dinmore, Ipswich Basin. Memoirs of the Queensland Museum 33: 360.

JELL, P.A. & DUNCAN, P.M. 1986. Invertebrates, mainly insects, from the freshwater, Lower Cretaceous, Koonwarra Fossil Bed (Korumburra Group), South Gippsland, Victoria. Memoirs of the Association of Australasian Palaeontologists 3: 111-205.

JELL, P.A. & LAMBKIN, K.J. 1993. Middle Triassic orthopteroid (Titanoptera) insect from the Esk Formation at Lake Wivenhoe. Memoirs of the Queensland Museum 33: 258.

JELL, P.A. & ROBERTS, J. (eds) 1986. Plants and invertebrates from the Lower Cretaceous, Koonwarra Fossil Bed, South Gippsland, Victoria. Memoirs of the Association of Australasian Palaeontologists 3: 1-205.

KOVALEV, V.G. 1983. New dipteran family from the Triassic of Australia and its presumed descendants (Diptera, Crosaphididae fam.n., Mycetobiidae). Entomology Review 62(4): 130-136.

KUKALOVÁ, J. 1966. Protelytroptera from the Upper Permian of Australia, with a discussion of the Protocoleoptera and Paracoleoptera. Psyche 73: 89-111, pl. 8.

KUKALOVÁ-PEK, J. 1988. A substitute name for the extinct genus *Stenelytron* Kukalová (Protelytroptera). Psyche 94: 339.

1991. Fossil history and the evolution of hexapod structures. Pp. 141-179. In CSIRO (ed.) The insects of Australia: A textbook for students and research workers. 2nd ed. vol. 1(Melbourne University Press: Carlton). 542p.

LAMBKIN, K.J. 1987. A re-examination of *Euporismites balli* Tillyard from the Palaeocene of Queensland (Neuroptera: Osmylidae: Kempyninae). Neuroptera International 4: 295-300.

1988. A re-examination of *Lithosmylidia* Riek from the Triassic of Queensland with notes on Mesozoic 'osmylid-like' fossil Neuroptera (Insecta : Neuroptera). Memoirs of the Queensland Museum 25: 445-458.

1992a. Re-examination of the venation of *Osmylopsychops spillerae* Tillyard from the Triassic of Queensland. Memoirs of the Queensland Museum 32: 183-188.

1992b. A record of *Austrosialis* Tillyard from the Queensland Palaeocene (Insecta: Megaloptera: Sialidae). Queensland Naturalist 31: 84-86.

LITTLE, M.P., BOYD, R.L., BRUNTON, J., IVES, M., RIGBY, R. &TOBIN, C. 1996. The Newcastle Coal Measures: stratigraphy, sedimentology and sequence stratigraphy. Pp. 77-84. In Proceedings of the 30th Newcastle Symposium on Advances in the study of the Sydney Basin (Newcastle University: University).

LUKASHEVICH, E.D. & SHCHERBAKOV, D.E. 1998. A new Triassic family of Diptera from Australia. Pp. 81-89. In Proceedings of the First International Paleoentomological Conference. (AMBA projects: Moscow).

MARTYNOVA, O.M. 1948. Data on the evolution of the Mecoptera. Trudy Paleontologicheskogo instituta akademii nauk SSSR 14: 1-76, pls 1-3.

McKEOWN, K.C. 1937. New fossil insect wings (Protohemiptera, Family Mesotitanidae). Records of the Australian Museum 20: 31-37, pls 4-7.

NAUMANN, I.D. 1993. The supposed Cretaceous ant *Cretacoformica explicata* Jell and Duncan (Hymenoptera). Journal of the Australian Entomological Society 32: 355-356.

PARFREY, S.M. 1996. Geological Survey of Queensland Catalogue of type, figured and cited

fossils. (Queensland Department of Mines & Energy: Brisbane). 268p.

RASNITSYN, A.P. 1992. *Strashila incredibilis*, a new enigmatic mecopteroid insect with possible siphonapteran affinities from the Upper Jurassic of Siberia. Psyche 99: 323-333.

RASNITSYN, A.P. & QUICKE, L.J. (eds) 2002. History of insects. (Kluwer: Dordrecht, Holland). 517p.

RIEK, E.F. 1950. A fossil mecopteran from the Triassic beds at Brookvale, N.S.W. Records of the Australian Museum 22: 254-256.

1952a. The fossil insects of the Tertiary Redbank Plains Series. Part 1: an outline of the fossil assemblage with description of the fossil insects of the Orders Mecoptera and Neuroptera. University of Queensland Papers, Department of Geology 4: 3-14, pls 1-2.

1952b. Fossil insects from the Tertiary sediments at Dinmore, Queensland. University of Queensland Papers, Department of Geology 4: 17-22, pl. 1.

1953. Fossil mecopteroid insects from the Upper Permian of New South Wales. Records of the Australian Museum 23: 55-87, pls 5-6.

1954a. The fossil Diptera of the Tertiary Redbank Plains series, Queensland. Proceedings of the Linnean Society of New South Wales 79: 58-60.

1954b. A re-examination of the Upper Tertiary mayflies described by Etheridge and Olliff from the Vegetable Creek tin-field. Records of the Australian Museum 23: 159-160, pl. 10.

1954c. Further Triassic insects from Brookvale, N.S.W. (Orders Orthoptera Saltatoria, Protorthoptera, Perlaria). Records of the Australian Museum 23: 161-168, pl. 11.

1954d. A second specimen of the dragonfly *Aeschnidiopsis flindersiensis* (Woodward) from the Queensland Cretaceous. Proceedings of the Linnean Society of New South Wales 79: 61-62.

1955. Fossil insects from the Triassic beds at Mt Crosby Queensland. Australian Journal of Zoology 3: 654-691, pls 1-4.

1956. A re-examination of the mecopteroid and orthopteroid fossils (Insecta) from the Triassic beds at Denmark Hill, Queensland, with descriptions of further specimens. Australian Journal of Zoology 4: 98-110, pls 1-2.

1962. Fossil insects from the Triassic at Hobart, Tasmania. Papers and Proceedings of the Royal Society of Tasmania 96: 39-40, pls 1-2.

1967a. Further evidence of the Panorpidae in the Australian Tertiary (Insecta: Mecoptera). Journal of the Australian Entomological Society 6: 71-72.

1967b. A fossil cockroach (Blattodea: Poroblattinidae) from Mt. Nicholas Coal Measures, Tasmania. Journal of the Australian Entomological Society 6: 73.

1968a. *Robinjohnia tillyardi* Martynova, a mecopteron from the Upper Permian of Belmont, New South Wales. Records of the Australian Museum 27: 299-302, pl. 44.

1968b. Undescribed fossil insects from the Upper Permian of Belmont, New South Wales (with an appendix listing the described species). Records of the Australian Museum 27: 303-310, pl. 45.

1968c. On the occurrence of fossil insects in the Mesozoic rocks of Western Australia. Records of the Australian Museum 27: 311-312, pl. 46.

1970a. Lower Cretaceous fleas. Nature 227: 746-747.

1970b. Origin of the Australian insect fauna. Pp. 593-598. In Theron (ed.) Proceedings and Papers of the Second Gondwana Symposium, South Africa, 1970.

1970c. Fossil history. Pp. 168-186. In CSIRO (ed.) The insects of Australia: A textbook for students and research workers. (Melbourne University Press: Carlton). 1029p.

1971. The presumed heads of Homoptera (Insecta) in the Australian Upper Permian. Palaeontology 14: 211-221.

1973. A Carboniferous insect from Tasmania. Nature 244: 455-456.

1976. Neosecoptera, a new insect suborder based on specimen discovered in the Late Carboniferous of Tasmania. Alcheringa 1: 227-234.

ROZEFELDS, A.C. 1985. A fossil zygopteran nymph (Insecta: Odonata) from the Late Triassic Aberdare Conglomerate, southeast Queensland. Proceedings of the Royal Society of Queensland 96: 25-32.

1988a. Insect leaf mines from the Eocene Anglesea locality, Victoria, Australia. Alcheringa 12: 1-6.

1988b. Lepidoptera mines in *Pachypteris* (Corystspermaceae: Pteridospermo- phyta) from the Upper Jurassic/Lower Cretaceous Battle Camp Formation, north Queensland. Proceedings of the Royal Society of Queensland 99: 77-81.

ROZEFELDS, A.C. & SOBBE, I. 1987. Problematic insect leaf mines from the Upper Triassic Ipswich Coal Measures of southeastern Queensland. Alcheringa 11: 51-57.

SHAROV, A.G. 1968. Phylogeny of the Orthopteroidea. Trudy Paleontologicheskogo Instituta Akademiya Nauk SSSR 118: 1-218.

SMITHERS, C.N. 1972. The classification and phylogeny of the Psocoptera. Memoirs of the Australian Museum 14:

SUKATCHEVA, I.D. 1982. Istoricheskoe razvitie otryada rucheinikov [Historical development of the caddisflies]. Trudy Paleontologicheskogo Instituta Akademiya Nauk SSSR 197: 1-107.

TALENT, J.A., DUNCAN, P.M. & HANDBY, P.L. 1966. Early Cretaceous feathers from Victoria. Emu 66: 81-86, pls 1-3.

TILLYARD, R.J. 1917. Mesozoic insects of Queensland. No. 1. Planipennia, Trichoptera, and the new order Protomecoptera. Proceedings of the

Linnean Society of New South Wales 42: 175-200, pls 7-9.

1918a. Mesozoic insects of Queensland. No. 2. The fossil dragonfly *Aeschnidiopsis (Aeschna) flindersiensis* Woodward), from the Rolling Downs (Cretaceous) Series. Proceedings of the Linnean Society of New South Wales 42: 676-692, pls 42-43.

1918b.Permian and Triassic insects from New South Wales, in the collection of Mr. John Mitchell. Proceedings of the Linnean Society of New South Wales 42: 720-756.

1918c. A fossil insect wing from the roof of the coal-seam in the Sydney Harbour Colliery. Proceedings of the Linnean Society of New South Wales 43: 260-264.

1918d. Mesozoic insects of Queensland. No. 3. Odonata and Protodonata. Proceedings of the Linnean Society of New South Wales 43: 417-436, pls 44-45.

1918e. Mesozoic insects of Queensland. No. 4. Hemiptera Heteroptera: the family Dunstaniidae with a note on the origin of the Heteroptera. Proceedings of the Linnean Society of New South Wales 43: 568-592, pl. 59.

1919a. Mesozoic insects of Queensland. No. 5. Mecoptera, the new order Paratrichoptera, and additions to Planipennia. Proceedings of the Linnean Society of New South Wales 44: 194-212, pl. 67.

1919b. A fossil insect wing belonging to the new order Paramecoptera, ancestral to the Trichoptera and Lepidoptera, from the upper Coal-Measures of Newcastle, N.S.W. Proceedings of the Linnean Society of New South Wales 44: 231-256, pls 12-13.

1919c. Mesozoic insects of Queensland. No. 6. Blattoidea. Proceedings of the Linnean Society of New South Wales 44: 358-382.

1919d. Mesozoic insects of Queensland. No. 7. Hemiptera Homoptera; with a note on the phylogeny of the suborder. Proceedings of the Linnean Society of New South Wales 44: 857-896, pls 7-9.

1921a. Mesozoic insects of Queensland. No. 8. Hemiptera Homoptera (Contd.). Proceedings of the Linnean Society of New South Wales 46: 270-284, pls 16-21.

1921b. Two fossil insect wings in the collection of Mr. John Mitchell, from the Upper Permian of Newcastle, N.S.W., belonging to the Order Hemiptera. Proceedings of the Linnean Society of New South Wales 46: 413-422, pl. 35.

1922a. Some new Permian insects from Belmont, N.S.W. in the collection of Mr John Mitchell. Proceedings of the Linnean Society of New South Wales 47: 279-292, pls 33-34.

1922b. Mesozoic insects of Queensland. No. 9. Orthoptera, and additions to the Protorthoptera, Odonata, Hemiptera and Planipennia. Proceedings of the Linnean Society of New South Wales 47: 447-470, pls 51-53.

1922c. An insect wing in a crystal of selenite (order Orthoptera). Records of the Geological Survey of New South Wales 10: 205-207, pl. 15.

1923a. On a Tertiary fossil insect wing from Queensland (Homoptera Fulgoroidea), with description of a new genus and species. Proceedings of the Royal Society of Queensland 35: 16-20, pl. 1.

1923b. Mesozoic insects of Queensland. No. 10. Summary of the Upper Triassic insect fauna of Ipswich, Q. (With an appendix describing new Hemiptera and Planipennia). Proceedings of the Linnean Society of New South Wales 48: 481-498, pl. 43.

1924. Upper Permian Coleoptera and a new order from the Belmont Beds, New South Wales. Proceedings of the Linnean Society of New South Wales 49: 429-435, pls 45-46.

1925. A new fossil insect wing from Triassic beds near Deewhy, N.S.W.. Proceedings of the Linnean Society of New South Wales 50: 374-377, pl. 36.

1926a. Upper Permian insects of New South Wales 1. Introduction and the Order Hemiptera. Proceedings of the Linnean Society of New South Wales 51: 1-30, pl. 1.

1926b. Upper Permian insects of New South Wales. 2. The orders Mecoptera, Paramecoptera and Neuroptera. Proceedings of the Linnean Society of New South Wales 51: 265-282, pls 15-16.

1929. Permian Diptera from Warner's Bay, N.S.W. Nature 123: 778-779.

1935a. Upper Permian insects of New South Wales. 3. The order Copeognatha. Proceedings of the Linnean Society of New South Wales 60: 265-279.

1935b. Upper Permian insects of New South Wales. 4. The order Odonata. Proceedings of the Linnean Society of New South Wales 60: 374-384, pl. 12.

1935c. Upper Permian insects of New South Wales. 5. The order Perlaria or stoneflies. Proceedings of the Linnean Society of New South Wales 60: 385-391, pl. 12.

1937. A small collection of fossil cockroach remains from the Triassic Beds of Mount Crosby, Queensland. Proceedings of the Royal Society of Queensland 48: 35-40.

1916. Mesozoic and Tertiary insects of Queensland and New South Wales. Description of the fossil insects. Geological Survey of Queensland Publication 253: 11-60, pls 1-7.

TINDALE, N.B. 1945. Triassic insects of Queensland. 1. *Eoses*, a probable lepidopterous insect from the Triassic beds of Mt. Crosby, Queensland. Proceedings of the Royal Society of Queensland 56: 37-46, pl. 5.

1980. Origin of the Lepidoptera, with description of a new mid-Triassic species and notes on the

origin of the butterfly stem. Journal of the Lepidopterists' Society 34: 263-285.

VISHNIAKOVA, V.N. 1981. New Palaeozoic and Mesozoic lophioneurids (Thripida, Lophioneuridae). Trudy Paleontologicheskogo instituta, Akad emiya Nauk SSSR 183: 43-63.

WALDMAN, M. 1971. Fish from the freshwater Lower Cretaceous of Victoria, Australia, with comments on the palaeo-environment. Special Papers in Palaeontology 9: 1-124, pls 1-18.

WHITWORTH, H.F. 1954. A faked fossil. Museums Journal 53: 319-320.

WILLMAN, R. 1989a. Rediscovered: *Permotipula patricia*, the oldest known fly. Naturwissenschaften 76: 375-377.

1989b. Evolution und Phylo- genetisches System der Mecoptera (Insecta: Holometabola). Abhandlungen der Sencken- bergischen Naturforschenden Gesellschaft 544: 1-153.

WOODWARD, H. 1884. On the wing of a neuropterous insect from the Cretaceous limestone of Flinders River, north Queensland, Australia. Geological Magazine, 3rd decade 1: 337-339, pl. 1.

WOOTON, R.J. 1963. Actinoscytinidae (Hemiptera-Heteroptera) from the upper Triassic of Queensland. Annals and Magazine of Natural History, series 13, 6: 249-255.