# APPENDIX A

**Appendix A.** The ingroup species (Eriophyoidea) and outgroup species (Tydeidae and Tetranychidae) included in the data sets in the present study of the phylogeny of the Eriophyoidea. All species are included in the 318 taxon data matrix. The number of species described in each genus mostly according to Amrine *et al.* (2003), or more recent, is listed in the column "Nu. spp."; Tydeidae - monotypic genus; Tetranychidae – according to Bolland *et al*. (1998).

| Mite species | Classification | Nu. spp. | Articles from which characters were scored in the present study |
|---|---|---|---|
| *Orfareptydeus stepheni* Ueckermann & Grout, 2007 | Tydeidae | 1 | Ueckermann & Grout, 2007 |
| *Mononychellus yemensis* Meyer, 1996 | Tetranychidae | 29 | Meyer, 1996 |
| *Abacarus acalyptus* (Keifer, 1939) | Eriophyidae: Phyllocoptinae: Anthocoptini | 50 | Keifer, 1939d |
| *Abacarus hystrix* (Nalepa, 1896) | Eriophyidae: Phyllocoptinae: Anthocoptini | 50 | Nalepa, 1896; Keifer, 1952b |
| *Aberoptus samoae* Keifer, 1951 | Eriophyidae: Aberoptinae | 3 | Keifer, 1951 |
| *Acadicrus bifurcatus* Keifer, 1965 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 3 | Keifer, 1965b |
| *Acalitus ledi* Keifer, 1965 | Eriophyidae: Eriophyinae: Aceriini | 87 | Keifer, 1965b |
| *Acamina nolinae* (Keifer, 1939) | Eriophyidae: Phyllocoptinae: Phyllocoptini | 2 | Keifer, 1939a |
| *Acaphyllisa parindiae* Keifer, 1978 | Eriophyidae: Phyllocoptinae: Acaricalini | 10 | Keifer, 1978 |
| *Acarelliptus cocciformis* Keifer, 1940 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 4 | Keifer, 1940b |
| *Acarhis diospyrosis* Chandrapatya, 1991 | Diptilomiopidae: Diptilomiopinae | 3 | Chandrapatya & Boczek, 1991c |
| *Acarhis lepisanthis* Keifer, 1975 | Diptilomiopidae: Diptilomiopinae | 3 | Keifer, 1975d |
| *Acarhis siamensis* Boczek & Chandrapatya, 2000 | Diptilomiopidae: Diptilomiopinae | 3 | Boczek & Chandrapatya, 2000 |
| *Acarhynchus filamentus* Keifer, 1959 | Diptilomiopidae: Diptilomiopinae | 5 | Keifer, 1959b |
| *Acaricalus segundus* Keifer, 1940 | Eriophyidae: Phyllocoptinae: Acaricalini | 15 | Keifer, 1940b |
| *Acathrix trymatus* Keifer, 1962 | Phytoptidae: Phytoptinae | 2 | Keifer, 1962c |
| *Aceria tulipae* (Keifer, 1938) | Eriophyidae: Eriophyinae: Aceriini | 900 | Keifer, 1938a |
| *Acerimina cedrelae* Keifer, 1957 | Eriophyidae: Eriophyinae: Aceriini | 7 | Keifer, 1957 |
| *Achaetocoptes ajoensis* (Keifer, 1961) | Eriophyidae: Cecidophyinae: Cecidophyini | 2 | Keifer, 1961a |
| *Acritonotus denmarki* Keifer,1962 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 2 | Keifer, 1962d |
| *Aculodes mckenziei* (Keifer, 1944) | Eriophyidae: Phyllocoptinae: Anthocoptini | 16 | Keifer, 1944 |
| *Aculops populivagrans* (Keifer, 1953) | Eriophyidae: Phyllocoptinae: Anthocoptini | 158 | Keifer, 1953 |
| *Aculus ligustri* (Keifer, 1938) | Eriophyidae: Phyllocoptinae: Anthocoptini | 248 | Keifer, 1938a |
| *Acunda plectilis* Keifer, 1965 | Eriophyidae: Eriophyinae: Aceriini | 1 | Keifer, 1965c |
| *Adenocolus psydraxi* Meyer & Ueckermann, 1997 | Eriophyidae: Nothopodinae: Colopodacini | 1 | Meyer & Ueckermann, 1997 |
| *Aequsomatus lanceolatae* Meyer & Ueckermann, 1995 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 3 | Meyer & Ueckermann, 1995 |
| *Africus psydraxae* Meyer & Ueckermann, 1995 | Diptilomiopidae: Diptilomiopinae | 1 | Meyer & Ueckermann, 1995 |
| *Afromerus florinoxus* Meyer, 1990 | Eriophyidae: Cecidophyinae: Colomerini | 5 | Meyer, 1990b |
| *Anchiphytoptus lineatus* Keifer, 1952 | Phytoptidae: Phytoptinae | 4 | Keifer, 1952a |
| *Anothopoda johnstoni* Keifer, 1959 | Eriophyidae: Nothopodinae: Nothopodini | 5 | Keifer, 1959d |
| *Anthocoptes gutierreziae* Keifer, 1962 | Eriophyidae: Phyllocoptinae: Anthocoptini | 50 | Keifer, 1962c |
| *Apodiptacus cordiformis* Keifer, 1960 | Diptilomiopidae: Diptilomiopinae | 5 | Keifer, 1960 |
| *Apontella bravaisiae* Boczek & Nuzzaci, 1988 | Eriophyidae: Nothopodinae: Colopodacini | 1 | Boczek & Nuzzaci, 1988 |
| *Arectus bidwillius* Manson, 1984 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 1 | Manson, 1984a |
| *Areekulus eugeniae* Chandrapatya, 1998 | Diptilomiopidae: Rhyncaphytoptinae | 1 | Boczek & Chandrapatya, 1998 |
| *Asetacus madronae* Keifer, 1952 | Diptilomiopidae: Rhyncaphytoptinae | 7 | Keifer, 1952a |
| *Asetadiptacus emiliae* Carmona, 1970 | Diptilomiopidae: Diptilomiopinae | 2 | Carmona, 1970 |
| *Asetilobus hodgkinsi* (Manson, 1965) | Eriophyidae: Eriophyinae: Eriophyini | 1 | Manson, 1965 |
| *Ashieldophyes pennadamensis* Mohanasundaram, 1984 | Eriophyidae: Ashieldophyinae | 1 | Mohanasundaram, 1984 |
| *Austracus havrylenkonis* Keifer, 1944 | Phytoptidae: Sierraphytoptinae: Sierraphytoptini | 1 | Keifer, 1944 |
| *Baileyna marianae* Keifer, 1954 | Eriophyidae: Eriophyinae: Aceriini | 5 | Keifer, 1954 |
| *Bakeriella ocimis* Chakrabarti & Mondal, 1982 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Chakrabarti & Mondal, 1982 |
| *Bariella farnei* De Lillo, 1988 | Eriophyidae: Cecidophyinae: Cecidophyini | 1 | De Lillo, 1988a |
| *Boczekella laricis* Farkas, 1965 | Phytoptidae: Nalepellinae: Trisetacini | 3 | Farkas, 1965a |
| *Brachendus pumilae* Keifer, 1964 | Eriophyidae: Eriophyinae: Eriophyini | 3 | Keifer, 1964a |
| *Brevulacus reticulatus* Manson, 1984 | Diptilomiopidae: Rhyncaphytoptinae | 1 | Manson, 1984a |
| *Bucculacus kaweckii* Boczek, 1961 | Diptilomiopidae: Diptilomiopinae | 2 | Boczek, 1961 |
| *Calacarus pulviferus* Keifer, 1940 | Eriophyidae: Phyllocoptinae: Calacarini | 41 | Keifer, 1940b |
| *Calepitrimerus cariniferus* Keifer, 1938 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 62 | Keifer, 1938b |
| *Caliphytoptus quercilobatae* Keifer, 1938 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 3 | Keifer, 1938b |
| *Caroloptes fagivagrans* Keifer, 1940 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 1 | Keifer, 1940b |
| *Catachella machaerii* Keifer, 1969 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Keifer, 1969b |
| *Catarhinus tricholaenae* Keifer, 1959 | Diptilomiopidae: Rhyncaphytoptinae | 11 | Keifer, 1959b |
| *Cecidodectes euzonus* Nalepa, 1917 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 2 | Meyer & Ueckermann, 1989b |
| *Cecidophyes rouhollahi* Craemer, 1999 | Eriophyidae: Cecidophyinae: Cecidophyini | 143 | Craemer *et al*., 1999 |
| *Cenaca syzygioidis* Keifer, 1972 | Eriophyidae: Eriophyinae: Aceriini | 3 | Keifer, 1972 |
| *Cenalox nyssae* Keifer, 1961 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 2 | Keifer, 1961b |
| *Cercodes simondsi* Keifer, 1960 | Eriophyidae: Eriophyinae: Eriophyini | 1 | Keifer, 1960 |
| *Chakrabartiella ficusis* (Chakrabarti, Ghosh & Das, 1992) | Diptilomiopidae: Rhyncaphytoptinae | 1 | Chakrabarti, Ghosh & Das, 1992 |
| *Cheiracus sulcatus* Keifer, 1977 | Diptilomiopidae: Rhyncaphytoptinae | 4 | Keifer, 1977a |
| *Chiangmaia longifolii* (Chandrapatya & Boczek, 2000) | Diptilomiopidae: Diptilomiopinae | 1 | Chandrapatya & Boczek, 2000c |
| *Chrecidus quercipodus* Manson, 1984 | Eriophyidae: Cecidophyinae: Cecidophyini | 1 | Manson, 1984a |
| *Circaces chakrabartii* Keifer, 1978 | Eriophyidae: Cecidophyinae: Colomerini | 4 | Keifer, 1978 |
| *Cisaberoptus kenyae* Keifer, 1966 (now jr. syn. of *Aceria*) | Eriophyidae: Aberoptinae | 2 | Keifer, 1966c (deutogyne) |
| *Cisaberoptus pretoriensis* Meyer, 1989 (now jr. syn. of *Aceria*) | Eriophyidae: Aberoptinae | 2 | Meyer, 1989a (deutogyne) |
| *Colomerus gardeniella* (Keifer, 1964) | Eriophyidae: Cecidophyinae: Colomerini | 25 | Keifer, 1964b |

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|---|---|---|---|
| *Colopodacus africanus* Keifer, 1960 | Eriophyidae: Nothopodinae: Colopodacini | 14 | Keifer, 1960 |
| *Coptophylla lamimani* (Keifer, 1939) | Eriophyidae: Cecidophyinae: Cecidophyini | 2 | Keifer, 1939d |
| *Cosella deleoni* (Keifer, 1956) | Eriophyidae: Nothopodinae: Nothopodini | 22 | Keifer, 1956 |
| *Cosetacus camelliae* (Keifer, 1945) | Eriophyidae: Cecidophyinae: Colomerini | 2 | Keifer, 1945 |
| *Costarectus zeyheri* Meyer & Ueckermann, 1995 | Eriophyidae: Phyllocoptinae: Anthocoptini | 2 | Meyer & Ueckermann, 1995 |
| *Criotacus brachystegiae* Keifer, 1963 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 6 | Keifer, 1963b |
| *Cupacarus cuprifestor* Keifer, 1943 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 6 | Keifer, 1943 |
| *Cymeda zealandica* Manson & Gerson, 1986 | Eriophyidae: Phyllocoptinae: Acaricalini | 1 | Manson & Gerson, 1986 |
| *Cymoptus spiniventris* Keifer, 1946 | Eriophyidae: Eriophyinae: Aceriini | 4 | Keifer, 1946 |
| *Dacundiopus stylosus* Manson, 1984 | Diptilomiopidae: Diptilomiopinae | 1 | Manson, 1984a |
| *Davisella breitlowi* (Davis, 1964) | Diptilomiopidae: Diptilomiopinae | 6 | Davis, 1964a |
| *Dechela epelis* Keifer, 1965 | Eriophyidae: Cecidophyinae: Cecidophyini | 1 | Keifer, 1965a |
| *Dialox stellatus* Keifer, 1962 | Diptilomiopidae: Diptilomiopinae | 1 | Keifer, 1962d |
| *Dichopelmus notus* , Keifer 1959 | Eriophyidae: Phyllocoptinae: Acaricalini | 4 | Keifer, 1959c |
| *Dicrothrix anacardii* Keifer, 1966 | Eriophyidae: Phyllocoptinae: Tegonotini | 2 | Keifer, 1966c |
| *Diphytoptus nephroideus* Huang, 1991 | Eriophyidae: Eriophyinae: Diphytoptini | 1 | Huang, 1991 |
| *Diptacus pandanus* (Boczek & Oleczek, 1988) | Diptilomiopidae: Diptilomiopinae | 43 | Boczek & Oleczek, 1988 |
| *Diptacus sacramentae* (Keifer, 1939) | Diptilomiopidae: Diptilomiopinae | 43 | Keifer, 1939b |
| *Diptilomiopus acronychia* Chen, Wei & Qin, 2004 | Diptilomiopidae: Diptilomiopinae | 82 | Chen, Wei & Qin, 2004 |
| *Diptilomiopus aglaiae* (Chandrapatya & Boczek, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 2002a |
| *Diptilomiopus alagarmalaiensis* Mohanasundaram, 1986 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1986a |
| *Diptilomiopus alangii* Mohanasundaram, 1982 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1982b |
| *Diptilomiopus anthocephaliae* (Chandrapatya & Boczek, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 2002a |
| *Diptilomiopus apobrevis* sp. nov. | Diptilomiopidae: Diptilomiopinae | 82 | present study |
| *Diptilomiopus apolongus* sp. nov. | Diptilomiopidae: Diptilomiopinae | 82 | present study |
| *Diptilomiopus aralioidus* Huang, 2006 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2006 |
| *Diptilomiopus artabotrysi* (Boczek, 1991) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1991b |
| *Diptilomiopus artocarpae* Mohanasundaram, 1981 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1981b |
| *Diptilomiopus asperis* Ghosh & Chakrabarti, 1989 | Diptilomiopidae: Diptilomiopinae | 82 | Ghosh & Chakrabarti, 1989a |
| *Diptilomiopus assamica* Keifer, 1959 | Diptilomiopidae: Diptilomiopinae | 82 | Keifer, 1959c |
| *Diptilomiopus averrhoae* Wei & Feng, 1999 | Diptilomiopidae: Diptilomiopinae | 82 | Wei & Feng, 1999 |
| *Diptilomiopus azadirachtae* (Boczek, 1992) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1992b |
| *Diptilomiopus barringtoniae* (Chandrapatya, 1992) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1992b |
| *Diptilomiopus bengalensis* Chakrabarti & Mondal, 1979 | Diptilomiopidae: Diptilomiopinae | 82 | Chakrabarti & Mondal, 1979 |
| *Diptilomiopus benjaminae* (Boczek & Chandrapatya, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 2002 |
| *Diptilomiopus boueae* (Chandrapatya & Boczek, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 2002a |
| *Diptilomiopus camarae* Mohanasundaram, 1981 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1981b |
| *Diptilomiopus cerberae* (Chandrapatya, 1998) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1998 |
| *Diptilomiopus championi* (Huang, 1992) | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 1992 |
| *Diptilomiopus cocculae* Mohanasundaram, 1981 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1981b |
| *Diptilomiopus combretae* (Chandrapatya & Boczek, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 2002a |
| *Diptilomiopus combreti* Wei & Lu, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Wei & Lu, 2001 |
| *Diptilomiopus commuiae* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001b |
| *Diptilomiopus coreiae* (Chandrapatya & Boczek, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 2002b |
| *Diptilomiopus cumingis* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001a |
| *Diptilomiopus cuminis* Chakrabarti, Ghosh & Das, 1992 | Diptilomiopidae: Diptilomiopinae | 82 | Chakrabarti, Ghosh & Das, 1992 |
| *Diptilomiopus cuminis* redescription by Huang (2001c) | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001c |
| *Diptilomiopus cythereae* (Chandrapatya, 1991) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1991a |
| *Diptilomiopus davisi* Keifer, 1969 | Diptilomiopidae: Diptilomiopinae | 82 | Keifer, 1969a |
| *Diptilomiopus dendropanacis* Chen, Wei & Qin, 2003 | Diptilomiopidae: Diptilomiopinae | 82 | Chen, Wei & Qin, 2003 |
| *Diptilomiopus elaeocarpi* (Boczek, 1991) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1991a |
| *Diptilomiopus elliptus* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001d |
| *Diptilomiopus emarginatus* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001c |
| *Diptilomiopus ervatamiae* (Chandrapatya, 1991) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1991a |
| *Diptilomiopus eucalypti* (Boczek, 1991) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1991b |
| *Diptilomiopus euryae* Chen, Wei & Qin, 2003 | Diptilomiopidae: Diptilomiopinae | 82 | Chen, Wei & Qin, 2003 |
| *Diptilomiopus faurius* sp. nov. | Diptilomiopidae: Diptilomiopinae | 82 | present study |
| *Diptilomiopus ficifolius* (Boczek & Oleczek, 1988) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Oleczek, 1988 |
| *Diptilomiopus ficus* Attiah, 1967 | Diptilomiopidae: Diptilomiopinae | 82 | Attiah, 1967 |
| *Diptilomiopus ficusis* Chakrabarti & Mondal, 1983 | Diptilomiopidae: Diptilomiopinae | 82 | Chakrabarti & Mondal, 1983 |
| *Diptilomiopus formosanus* Huang, 2005 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2005 |
| *Diptilomiopus gilibertiae* Kadono, 1984 | Diptilomiopidae: Diptilomiopinae | 82 | Kadono, 1984 |
| *Diptilomiopus guajavae* Mohanasundaram, 1985 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1985 |
| *Diptilomiopus hexogonus* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001c |
| *Diptilomiopus holmesi* (Keifer, 1962) | Diptilomiopidae: Diptilomiopinae | 82 | Keifer, 1962c |
| *Diptilomiopus holopteleae* Abou-Awad & El-Banhawy, 1992 | Diptilomiopidae: Diptilomiopinae | 82 | Abou-Awad & El-Banhawy, 1992 |
| *Diptilomiopus holoptelus* Chakrabarti & Mondal, 1983 | Diptilomiopidae: Diptilomiopinae | 82 | Chakrabarti & Mondal, 1983 |
| *Diptilomiopus illicii* Wei & Lu, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Wei & Lu, 2001 |
| *Diptilomiopus indicus* Chakrabarti & Pandit, 1996 | Diptilomiopidae: Diptilomiopinae | 82 | Chakrabarti & Pandit, 1996 |

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| *Diptilomiopus integrifoliae* Mohanasundaram, 1981 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1981b |
| *Diptilomiopus jasminiae* (Chandrapatya & Boczek, 2001) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 2001a |
| *Diptilomiopus javanicus* Nalepa, 1916 | Diptilomiopidae: Diptilomiopinae | 82 | Nalepa, 1916; Nalepa, 1918 |
| *Diptilomiopus jevremovici* Keifer, 1960 | Diptilomiopidae: Diptilomiopinae | 82 | Keifer, 1960 |
| *Diptilomiopus knorri* Keifer, 1974 | Diptilomiopidae: Diptilomiopinae | 82 | Keifer, 1974 |
| *Diptilomiopus languasi* (Boczek, 1991) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1991b |
| *Diptilomiopus leeasis* Chakrabarti, Ghosh & Das, 1992 | Diptilomiopidae: Diptilomiopinae | 82 | Chakrabarti, Ghosh & Das, 1992 |
| *Diptilomiopus leptophyllus* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001c |
| *Diptilomiopus lobbianus* Huang & Cheng, 2005 | Diptilomiopidae: Diptilomiopinae | 82 | Huang & Cheng, 2005 |
| *Diptilomiopus loropetali* Kuang, 1986 | Diptilomiopidae: Diptilomiopinae | 82 | Kuang, 1986a; Hong & Zhang, 1996c |
| *Diptilomiopus maduraiensis* Mohanasundaram, 1986 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1986a |
| *Diptilomiopus malloti* Wei & Feng, 1999 | Diptilomiopidae: Diptilomiopinae | 82 | Wei & Feng, 1999 |
| *Diptilomiopus melastomae* (Boczek & Chandrapatya, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 2002 |
| *Diptilomiopus meliae* (Boczek, 1998) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1998 |
| *Diptilomiopus morii* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001c |
| *Diptilomiopus morindae* (Boczek, 1998) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1998 |
| *Diptilomiopus musae* (Chandrapatya, 1998) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1998 |
| *Diptilomiopus octogonus* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001c |
| *Diptilomiopus pamithus* (Boczek & Chandrapatya, 1989) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1989 |
| *Diptilomiopus perfectus* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001c |
| *Diptilomiopus phylanthi* (Chandrapatya, 1992) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1992b |
| *Diptilomiopus pocsi* Farkas, 1967 | Diptilomiopidae: Diptilomiopinae | 82 | Farkas, 1967 |
| *Diptilomiopus racemosae* (Chandrapatya & Boczek, 2001) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 2001a |
| *Diptilomiopus riciniae* (Boczek & Chandrapatya, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 2002 |
| *Diptilomiopus sandorici* (Chandrapatya, 1991) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1991a |
| *Diptilomiopus securinegus* Boczek, 1992 | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1992a |
| *Diptilomiopus septimus* Huang, 2001 (now jr. syn. of *D. championi*) | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2001c |
| *Diptilomiopus stephanus* Huang, 2005 | Diptilomiopidae: Diptilomiopinae | 82 | Huang, 2005 |
| *Diptilomiopus strebli* (Boczek, 1992) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 1992b |
| *Diptilomiopus swieteniae* (Chandrapatya, 1998) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1998 |
| *Diptilomiopus thaianae* (Boczek, 1991) | Diptilomiopidae: Diptilomiopinae | 82 | Chandrapatya & Boczek, 1991a |
| *Diptilomiopus thangaveli* Mohanasundaram, 1983 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1983c |
| *Diptilomiopus thunbergiae* (Boczek & Chandrapatya, 2002) | Diptilomiopidae: Diptilomiopinae | 82 | Boczek & Chandrapatya, 2002 |
| *Diptilomiopus trewier* Chakrabarti & Mondal, 1983 | Diptilomiopidae: Diptilomiopinae | 82 | Chakrabarti & Mondal, 1983 |
| *Diptilomiopus ulmivagrans* Mohanasundaram, 1984 | Diptilomiopidae: Diptilomiopinae | 82 | Mohanasundaram, 1984 |
| *Diptiloplatus megagrastis* Keifer, 1975 | Diptilomiopidae: Diptilomiopinae | 2 | Keifer, 1975c |
| *Diptilorhynacus dioscoreae* Boczek & Nuzzaci, 1985 | Diptilomiopidae: Diptilomiopinae | 2 | Boczek & Nuzzaci, 1985 |
| *Diptilorhynacus sinusetus* Mondal, Ghosh & Chakrabarti, 1981 | Diptilomiopidae: Diptilomiopinae | 2 | Mondal, Ghosh & Chakrabarti, 1981 |
| *Diptilostatus nudipalpus* Flechtmann, 2003 | Diptilomiopidae: Diptilomiopinae | 2 | Flechtmann & De Moraes, 2003 |
| *Disella ilicis* (Keifer, 1965) | Eriophyidae: Nothopodinae: Nothopodini | 12 | Keifer, 1965a |
| *Ditrymacus athiasella* Keifer, 1960 | Eriophyidae: Phyllocoptinae: Anthocoptini | 3 | Keifer, 1960 |
| *Duabangus chiangmai* Chandrapatya & Boczek, 2000 | Diptilomiopidae: Diptilomiopinae | 1 | Chandrapatya & Boczek, 2000b |
| *Ectomerus anysis* (Keifer, 1970) | Eriophyidae: Cecidophyinae: Colomerini | 4 | Keifer, 1970 |
| *Epicecidophyes clerodendris* Mondal & Chakrabarti, 1981 | Eriophyidae: Cecidophyinae: Colomerini | 2 | Mondal & Chakrabarti, 1981 |
| *Epiphytimerus palampurensis* Mohanasundaram, 1984 (now jr. syn. of *Abacarus*) | Eriophyidae: Phyllocoptinae: Anthocoptini | 1? | Mohanasundaram, 1984 |
| *Epitrimerus pyri* (Nalepa, 1891) | Eriophyidae: Phyllocoptinae: Phyllocoptini | 151 | Manson, 1984a |
| *Eriophyes pyri* (Pagenstecher, 1857) | Eriophyidae: Eriophyinae: Eriophyini | 299 | Manson, 1984b |
| *Eriophyes quadrifidus* Meyer & Ueckermann, 1989 | Eriophyidae: Eriophyinae: Eriophyini | 299 | Meyer & Ueckermann, 1989a |
| *Euterpia fissa* Navia & Flechtmann, 2005 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 1 | Navia & Flechtmann, 2005 |
| *Floracarus calonyctionis* Keifer, 1953 | Eriophyidae: Nothopodinae: Nothopodini | 18 | Keifer, 1953 |
| *Fragariocoptes setiger* (Nalepa, 1894) | Phytoptidae: Sierraphytoptinae: Sierraphytoptini | 1 | Roivainen, 1951; Boczek, 1964 |
| *Gammaphytoptus camphorae* Keifer, 1939 | Eriophyidae: Cecidophyinae: Colomerini | 5 | Keifer, 1939a |
| *Glyptacus lithocarpi* Keifer, 1953 | Eriophyidae: Cecidophyinae: Cecidophyini | 4 | Keifer, 1953 |
| *Heterotergum gossypii* Keifer, 1955 | Eriophyidae: Phyllocoptinae: Anthocoptini | 13 | Keifer, 1955 |
| *Hoderus roseus* (Keifer, 1975) | Diptilomiopidae: Rhyncaphytoptinae | 2 | Keifer, 1975d |
| *Hyborhinus kallarensis* Muhanasundaram, 1986 | Diptilomiopidae: Rhyncaphytoptinae | 1 | Mohanasundaram, 1986a |
| *Indonotolox sudarsani* Ghosh & Chakrabarti, 1982 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 1 | Ghosh & Chakrabarti, 1982 |
| *Indosetacus rhinacanthi* Ghosh & Chakrabarti, 1987 | Eriophyidae: Cecidophyinae: Colomerini | 1 | Ghosh & Chakrabarti, 1987 |
| *Indotegolophus darjeelingensis* Chakrabarti & Mondal, 1980 | Eriophyidae: Phyllocoptinae: Anthocoptini | 2 | Chakrabarti, Mondal & Roy, 1980 |
| *Johnella virginiana* Keifer, 1959 | Eriophyidae: Cecidophyinae: Cecidophyini | 2 | Keifer, 1959d |
| *Jutarus benjaminae* Boczek & Chandrapatya, 1989 | Eriophyidae: Phyllocoptinae: Calacarini | 2 | Boczek & Chandrapatya, 1989 |
| *Kaella flacourtiae* (Chandrapatya & Boczek, 2002) | Diptilomiopidae: Diptilomiopinae | 1 | Chandrapatya & Boczek, 2002b |
| *Keiferana neolitseae* Channabasavanna, 1967 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Channabasavanna, 1967 |
| *Keiferella juniperici* Boczek, 1964 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 3 | Boczek, 1964 |
| *Keiferophyes avicenniae* Mohanasundaram, 1983 | Eriophyidae: Eriophyinae: Aceriini | 2 | Mohanasundaram, 1983a |
| *Knorella gigantochloae* Keifer, 1975 | Eriophyidae: Phyllocoptinae: Acaricalini | 8 | Keifer, 1975c |
| *Konola hibernalis* Keifer, 1979 | Diptilomiopidae: Rhyncaphytoptinae | 1 | Keifer, 1979b |
| *Lambella cerina* (Lamb, 1953) | Diptilomiopidae: Diptilomiopinae | 1 | Manson, 1984a |

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| *Latinotus wegoreki* Boczek, 1960 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 1 | Boczek, 1960 |
| *Leipothrix solidaginis* Keifer, 1966 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 12 | Keifer, 1966c |
| *Levonga caseariasis* (Chakrabarti & Pandit, 1996) | Diptilomiopidae: Diptilomiopinae | 6 | Chakrabarti & Pandit, 1996 |
| *Levonga litseae* (Chakrabarti, Ghosh & Das, 1992) | Diptilomiopidae: Diptilomiopinae | 6 | Chakrabarti, Ghosh & Das, 1992 |
| *Levonga papaitongensis* Manson, 1984 | Diptilomiopidae: Diptilomiopinae | 6 | Manson, 1984a |
| *Litaculus khandus* Manson, 1984 | Eriophyidae: Phyllocoptinae: Acaricalini | 6 | Manson, 1984a |
| *Lithocarus thomsoni* Chandrapatya & Boczek, 2000 | Diptilomiopidae: Diptilomiopinae | 1 | Chandrapatya & Boczek, 2000c |
| *Mackiella phoenicis* Keifer, 1939 | Phytoptidae: Sierraphytoptinae: Mackiellini | 2 | Keifer, 1939a |
| *Mediugum sanasaii* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 1 | Huang, 2001d |
| *Mesalox tuttlei* Keifer, 1962 | Eriophyidae: Phyllocoptinae: Anthocoptini | 7 | Keifer, 1962a |
| *Metaculus syzygii* Keifer, 1962 | Eriophyidae: Phyllocoptinae: Anthocoptini | 10 | Keifer, 1962b |
| *Metaplatyphytoptus amoni* Hong & Kuang, 1989 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 2 | Hong & Kuang, 1989 |
| *Meyerella bicristatus* (Meyer, 1989) | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Meyer, 1989b |
| *Monotrymacus quadrangulari* Mohanasundaram, 1982 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 2 | Mohanasundaram, 1982a |
| *Nacerimina gutierrezi* Keifer, 1979 | Eriophyidae: Eriophyinae: Eriophyini | 2 | Keifer, 1979a |
| *Nalepella tsugifoliae* Keifer, 1953 | Phytoptidae: Nalepellinae: Nalepellini | 15 | Keifer, 1953 |
| *Neoacaphyllisa lithocarpi* Kuang & Hong, 1989 | Eriophyidae: Phyllocoptinae: Acaricalini | 1 | Kuang & Hong, 1989 |
| *Neoacarhis aglaiae* Kuang, 1998 | Diptilomiopidae: Diptilomiopinae | 1 | Kuang, 1998 |
| *Neocatarhinus bambusae* Kuang & Hong, 1990 | Diptilomiopidae: Rhyncaphytoptinae | 1 | Kuang & Hong, 1990 |
| *Neocecidophyes mallotivagrans* Muhanasundaram, 1980 | Eriophyidae: Cecidophyinae: Colomerini | 2 | Mohanasundaram, 1980 |
| *Neocolopodacus mitragynae* Mohanasundaram, 1980 | Eriophyidae: Phyllocoptinae: Anthocoptini | 2 | Mohanasundaram, 1980 |
| *Neocosella ichnocarpae* Mohanasundaram, 1981 | Eriophyidae: Nothopodinae: Nothopodini | 2 | Mohanasundaram, 1981d |
| *Neocupacarus flabelliferis* Das & Chakrabarti, 1985 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 1 | Das & Chakrabarti, 1985 |
| *Neodialox palmyrae* Mohanasundaram, 1983 | Diptilomiopidae: Diptilomiopinae | 1 | Mohanasundaram, 1983b |
| *Neodichopelmus samoanus* Manson, 1973 | Eriophyidae: Phyllocoptinae: Acaricalini | 1 | Manson, 1973 |
| *Neodicrothrix tiliacorae* Mohanasundaram, 1984 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 4 | Mohansundaram, 1984 |
| *Neodiptilomiopus vishakantai* Mohanasundaram, 1982 | Diptilomiopidae: Diptilomiopinae | 1 | Mohanasundaram, 1982b |
| *Neolambella ligustri* Lin & Kuang, 1997 | Diptilomiopidae: Diptilomiopinae | 1 | Lin & Kuang, 1997 |
| *Neomesalox kallarensis* Mohanasundaram, 1983 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Mohanasundaram, 1983a |
| *Neometaculus bauhiniae* Mohanasundaram, 1983 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 4 | Mohanasundaram, 1983a |
| *Neophantacrus mallotus* Mohanasundaram, 1981 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Mohanasundaram, 1981c |
| *Neophytoptus ocimae* Mohanasundaram, 1981 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 1 | Mohanasundaram, 1981a |
| *Neopropilus jatrophus* Huang, 1992 | Phytoptidae: Sierraphytoptinae: Sierraphytoptini | 1 | Huang, 1992 |
| *Neorhynacus rajendrani* Mohanasundaram, 1981 | Diptilomiopidae: Diptilomiopinae | 1 | Mohanasundaram, 1981b |
| *Neotegonotus fastigatus* (Nalepa, 1892) | Eriophyidae: Phyllocoptinae: Tegonotini | 5 | Keifer, 1961a |
| *Neserella decora* Meyer & Ueckermann, 1989 | Eriophyidae: Cecidophyinae: Cecidophyini | 4 | Meyer & Ueckermann, 1989b |
| *Norma lanyuensis* Huang, 2001 | Diptilomiopidae: Diptilomiopinae | 1 | Huang, 2001a |
| *Notacaphylla chinensiae* Mohanasundaram & Singh, 1988 | Eriophyidae: Phyllocoptinae: Acaricalini | 3 | Mohanasundaram & Singh, 1988 |
| *Notaceria tetrandiae* Mohanasundaram & Muniappan, 1990 [emendation by Amrine *et al*. (2003) to *tetrandrae*] | Eriophyidae: Eriophyinae: Aceriini | 1 | Mohanasundaram & Muniappan, 1990 |
| *Notallus nerii* Keifer, 1975 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Keifer, 1975c |
| *Nothacus tuberculatus* Manson, 1984 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Manson, 1984a |
| *Nothopoda rapaneae* Keifer, 1951 | Eriophyidae: Nothopodinae: Nothopodini | 10 | Keifer, 1951 |
| *Notostrix attenuata* Keifer, 1963 | Eriophyidae: Phyllocoptinae: Anthocoptini | 7 | Keifer, 1963a |
| *Novophytoptus rostratae* Roivainen, 1947 | Phytoptidae: Novophytoptinae | 6 | Roivainen, 1947 |
| *Novophytoptus stipae* Keifer, 1962 | Phytoptidae: Novophytoptinae | 6 | Keifer, 1962d |
| *Oziella yuccae* (Keifer, 1954) | Phytoptidae: Phytoptinae | 2 | Keifer, 1954; Amrine *et al*., 2003 |
| *Palmiphytoptus oculatus* Navia & Flechtmann, 2002 | Phytoptidae: Sierraphytoptinae: Mackiellini | 1 | Navia & Flechtmann, 2002 |
| *Pangacarus grisalis* Manson, 1984 | Eriophyidae: Nothopodinae: Nothopodini | 1 | Manson, 1984a |
| *Paracalacarus podocarpi* Keifer, 1962 | Eriophyidae: Phyllocoptinae: Calacarini | 1 | Keifer, 1962d |
| *Paracaphylla streblae* Mohanasundaram, 1983 | Eriophyidae: Phyllocoptinae: Acaricalini | 2 | Mohanasundaram, 1983b |
| *Paraciota tetracanthae* Mohanasundaram, 1984 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Mohanasundaram, 1984 |
| *Paracolomerus casimiroae* Keifer, 1975 | Eriophyidae: Cecidophyinae: Colomerini | 2 | Keifer, 1975c |
| *Paraphytoptella arnaudi* Keifer, 1959 | Eriophyidae: Eriophyinae: Aceriini | 2 | Keifer, 1959b |
| *Pararhynacus photiniae* Kuang, 1986 | Diptilomiopidae: Diptilomiopinae | 1 | Kuang, 1986a; Hong & Zhang, 1996c |
| *Pareria fremontiae* Keifer, 1952 | Eriophyidae: Eriophyinae: Eriophyini | 1 | Keifer, 1952a |
| *Pentamerus rhamnicroceae* (Keifer, 1966) | Eriophyidae: Phyllocoptinae: Anthocoptini | 5 | Keifer, 1966a |
| *Pentaporca taiwanensis* Huang, 1996 | Phytoptidae: Nalepellinae: Nalepellini | 1 | Huang & Boczek, 1996 |
| *Pentasetacus araucaria* Schliesske, 1985 | Phytoptidae: Nalepellinae: Pentasetacini | 1 | Schliesske, 1985 |
| *Peralox insolita* Keifer, 1962 | Diptilomiopidae: Rhyncaphytoptinae | 3 | Keifer, 1962b |
| *Phantacrus lobatus* Keifer, 1965 | Phytoptidae: Nalepellinae: Nalepellini | 1 | Keifer, 1965c |
| *Phyllocoptes calisorbi* Keifer, 1965 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 165 | Keifer, 1965a |
| *Phyllocoptruta arga* Styer & Keifer, 1977 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 23 | Keifer, 1977b |
| *Phyllocoptruta oleivora* (Ashmead, 1879) | Eriophyidae: Phyllocoptinae: Phyllocoptini | 23 | Keifer, 1938a |
| *Phytoptus avellanae* Nalepa, 1889 | Phytoptidae: Phytoptinae | 38 | Keifer, 1952b |
| *Platyphytoptus sabinianae* Keifer, 1938 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 13 | Keifer, 1938a |
| *Porcupinotus humpae* Mohanasundaram, 1984 | Eriophyidae: Phyllocoptinae: Anthocoptini | 2 | Mohanasundaram, 1984 |
| *Porosus monosporae* Meyer & Ueckermann, 1995 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Meyer & Ueckermann, 1995 |
| *Proartacris pinivagrans* Mohanasundaram, 1984 | Eriophyidae: Eriophyinae: Eriophyini | 3 | Mohanasundaram, 1984 |

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|---|---|---|---|
| *Prodiptilomiopus auriculatae* Umapathy & Mohanasundaram, 1999 | Diptilomiopidae: Diptilomiopinae | 1 | Umapathy & Mohanasundaram, 1999 |
| *Proneotegonotus antiquorae* Mohanasundaram, 1983 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 2 | Mohanasundaram, 1983a |
| *Prophyllocoptes riveae* Mohanasundaram, 1984 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 1 | Mohanasundaram, 1984 |
| *Propilus gentyi* Keifer, 1975 | Phytoptidae: Sierraphytoptinae: Mackiellini | 4 | Keifer, 1975d |
| *Prothrix aboula* Keifer, 1965 | Phytoptidae: Prothricinae | 1 | Keifer, 1965a |
| *Pyelotus africanae* Meyer, 1992 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Meyer, 1992c |
| *Quadracus urticarius* (Canestrini & Massalongo, 1893) | Diptilomiopidae: Rhyncaphytoptinae | 5 | Liro, 1941; Boczek & Kropczynska, 1965; Keifer, 1952b |
| *Quadriporca samphramae* (Boczek, 1997) (= *Q. indicae*, = *Kropczynella mangiferae*) | Diptilomiopidae: Rhyncaphytoptinae | 3 | Chandrapatya & Boczek, 1997a; Amrine & De Lillo, 2003 |
| *Quadriporca mangiferae* Kuang & Cheng, 1991 | Diptilomiopidae: Rhyncaphytoptinae | 3 | Hong & Zhang, 1996c |
| *Quintalitus squamosus* Meyer, 1989 | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Meyer, 1989c |
| *Ramaculus mahoe* Manson, 1984 | Eriophyidae: Eriophyinae: Aceriini | 2 | Manson, 1984b |
| *Rectalox falita* Manson, 1984 | Eriophyidae: Phyllocoptinae: Anthocoptini | 2 | Manson, 1984a |
| *Retracrus johnstoni* Keifer, 1965 | Phytoptidae: Sierraphytoptinae: Mackiellini | 2 | Keifer, 1965c |
| *Rhinophytoptus concinnus* Liro, 1943 | Diptilomiopidae: Rhyncaphytoptinae | 14 | Liro, 1943 |
| *Rhinotergum schestovici* Petanovic, 1988 | Diptilomiopidae: Rhyncaphytoptinae | 4 | Petanovic, 1988 |
| *Rhombacus morrisi* Keifer, 1965 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 7 | Keifer, 1965b |
| *Rhynacus arctostaphyli* (Keifer, 1938) | Diptilomiopidae: Diptilomiopinae | 3 | Keifer, 1938b |
| *Rhyncaphytoptus ficifoliae* Keifer, 1939 | Diptilomiopidae: Rhyncaphytoptinae | 80 | Keifer, 1939a |
| *Sakthirhynchus canariae* Umapathy & Mohanasundarm, 1999 | Diptilomiopidae: Rhyncaphytoptinae | 1 | Umapathy & Mohanasundaram, 1999 |
| *Schizacea gynerii* Keifer, 1977 | Eriophyidae: Phyllocoptinae: Acaricalini | 2 | Keifer, 1977a |
| *Schizoempodium mesophyllincola* Oldfield, Hunt & Gispert, 1998 | Eriophyidae: Eriophyinae: Diphytoptini | 1 | Oldfield, Hunt & Gispert, 1998 |
| *Scoletoptus duvernoiae* Meyer, 1992 | Eriophyidae: Eriophyinae: Aceriini | 1 | Meyer, 1992a |
| *Setoptus jonesi* (Keifer, 1938) | Phytoptidae: Nalepellinae: Nalepellini | 14 | Keifer, 1938a; Keifer, 1944 |
| *Shevtchenkella juglandis* (Keifer, 1951) | Eriophyidae: Phyllocoptinae: Tegonotini | 58 | Keifer, 1951 |
| *Sierraphytoptus alnivagrans* Keifer, 1939 | Phytoptidae: Sierraphytoptinae: Sierraphytoptini | 1 | Keifer, 1939a |
| *Sinacus erythrophlei* Hong & Kuang, 1989 | Eriophyidae: Phyllocoptinae: Anthocoptini | 2 | Hong & Kuang, 1989 |
| *Stenacis palomaris* Keifer, 1970 | Eriophyidae: Eriophyinae: Eriophyini | 8 | Keifer, 1970 |
| *Stenarhynchus aristidus* Mohanasundaram, 1983 | Diptilomiopidae: Rhyncaphytoptinae | 1 | Mohanasundaram, 1983c |
| *Steopa bauhiniae* (Chandrapatya & Boczek, 2001) | Diptilomiopidae: Diptilomiopinae | 1 | Chandrapatya & Boczek, 2001b |
| *Suthamus chiangmi* Chandrapatya & Boczek, 2000 | Diptilomiopidae: Diptilomiopinae | 1 | Chandrapatya & Boczek, 2000a |
| *Tegolophus califraxini* (Keifer, 1938) | Eriophyidae: Phyllocoptinae: Anthocoptini | 52 | Keifer, 1938b |
| *Tegonotus mangiferae* (Keifer, 1946) | Eriophyidae: Phyllocoptinae: Tegonotini | 46 | Keifer, 1946 |
| *Tegoprionus dentatus* (Nalepa, 1894) | Eriophyidae: Phyllocoptinae: Anthocoptini | 1 | Keifer, 1961a |
| *Tergilatus sparsus* Meyer & Ueckermann, 1995 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 2 | Meyer & Ueckermann, 1995 |
| *Tetra concava* (Keifer, 1939) | Eriophyidae: Phyllocoptinae: Anthocoptini | 87 | Keifer, 1939e |
| *Tetraspinus lentus* Boczek, 1961 | Eriophyidae: Phyllocoptinae: Anthocoptini | 8 | Boczek, 1961 |
| *Thailandus diospyrosae* Chandrapatya, 1997 | Diptilomiopidae: Diptilomiopinae | 1 | Chandrapatya & Boczek, 1997b |
| *Thamnacus rhamnicolus* (Keifer, 1938) | Eriophyidae: Phyllocoptinae: Anthocoptini | 7 | Keifer, 1938b |
| *Trimeracarus heptapleuri* Farkas, 1963 | Eriophyidae: Eriophyinae: Eriophyini | 1 | Farkas, 1963 |
| *Trimeroptes aleyrodiformis* (Keifer, 1940) | Diptilomiopidae: Diptilomiopinae | 3 | Keifer, 1940b |
| *Trisetacus ehmanni* Keifer, 1963 | Phytoptidae: Nalepellinae: Trisetacini | 56 | Keifer, 1963b |
| *Trisetacus pini* (Nalepa, 1887) | Phytoptidae: Nalepellinae: Trisetacini | 56 | Keifer, 1963b |
| *Tumescoptes trachycarpi* Keifer, 1939 | Eriophyidae: Phyllocoptinae: Acaricalini | 4 | Keifer, 1939c |
| *Ursynovia ulmi* Boczek & Szymkowiak, 1997 (now jr. syn. of *Tetra*) | Eriophyidae: Phyllocoptinae: Anthocoptini | 1? | Boczek & Szymkowiak, 1997 |
| *Vasates quadripedes* Shimer, 1869 | Eriophyidae: Phyllocoptinae: Phyllocoptini | 27 | Keifer, 1959b |
| *Vimola syzygii* Boczek, 1992 | Diptilomiopidae: Diptilomiopinae | 9 | Boczek & Chandrapatya, 1992a |
| *Vittacus mansoni* Keifer, 1969 | Eriophyidae: Phyllocoptinae: Anthocoptini | 4 | Keifer, 1969b |

# Appendix B

## CHARACTERS CODED FOR PHYLOGENETIC ANALYSES: DEFINITION, DESCRIPTION AND DISCUSSION.

# APPENDIX B

## CHARACTERS CODED FOR PHYLOGENETIC ANALYSES: DEFINITION, DESCRIPTION AND DISCUSSION.

Only one complete character discussion was prepared. To facilitate the retrieval of the complete character discussion of each character, regardless of its different character numbers in the different data sets, an abbreviated character list and the character numbers of the three character data sets (for 318, 66 and 18 taxa) are listed in the same table, accompanied by two additional tables with the character numbers of the 66- and 18-taxon data sets in order (Appendix C).

The character marked *** is the same for all taxa in data set (ingroup and outgroup species), characters marked with * are autapomorphic to the Eriophyoidea, and characters marked with ** are autapomorphic for a terminal Eriophyoidea species. These characters did not provide information for determining relationships among the Eriophyoidea (ingroup) taxa in the analyses. Some character states and their terminology are illustrated in Figs 3.2-3.6, 3.22. Only one side of the organism is described, apart from the description of the prodorsal shield pattern (see Chapter 3 and 4: Material and Methods). Character states were scored from published descriptions, either from the text description and/or descriptive drawing accompanying it. Discrepancies and ambiguousness are noted.

## GENERAL

### *0. Life cycle:

0 = four active immature instars
1 = three active immature instars
2 = two active immature instars

The life cycle of the Tydeidae, including *Orfareptydeus stepheni*, has four (larva, proto-, deuto- and tritonymph), and that of the Tetranychidae, including *Mononychellus yemensis*, three active immature instars (larva, deuto- and tritonymph) (Evans, 1992). The Eriophyoidea have two active immature instars [larva and nymph or proto- and deutonymph depending on the interpretation of the author (Lindquist, 1996a)].

Characters 1 - 5. The absence of a respiratory system with associated stigmata, an excretory system, cross-striated muscles, tonofibrillary muscle attachments, and absence of basal membranes around some organs (Lindquist, 1996b) are all autapomorphic character states for the Eriophyoidea in the present study. A priori phylogenetic analyses Lindquist (1996b) argued they may be ancestral (plesiomorphic) or derived (apomorphic) in the Eriophyoidea. If these states are primitive conditions rather than reversals, the Eriophyoidea may possibly be outside the Prostigmata or even outside the Acariformes, and the group may be an extremely ancient, independent group of very early chelicerate arthropodans (Lindquist, 1996b).

### *1. Respiratory system with stigmata – presence:

0 = present
1 = absent

A respiratory system, including tracheae and stigmata, with the stigmata located on the gnathosoma or on the dorsal and anterolateral surface of the prodorsum, is present in the Prostigmata (Evans, 1992). A Prostigmata type respiratory system is present in *O. stepheni* and *M. yemensis*.

A typical respiratory system is absent in the Eriophyoidea. Shevchenko & Silvere (1968) speculated that the motivator between the bases of the chelicerae is a modified relict of a tracheal system, and Krantz (1973) speculated that the pair of structures arising just posterior to the motivator may be tracheal trunks. Respiration in the eriophyoids is cuticular (Nuzzaci & Alberti, 1996), however, and no confirmed evidence exists of the contrary (Lindquist, 1996b).

### *2. Excretory system – presence:

0 = present
1 = absent, only with pervasive parenchymatous tissue

An excretory system, including an anus, is present in *O. stepheni* (Fig. 4.1) and in *M. yemensis* (Fig. 4.2), but is absent in the Eriophyoidea where the excretory system exists only of pervasive parenchymatous tissue (Lindquist, 1996b).

### *3. Muscle striation:

0 = cross-striated
1 = non-striated

The muscles of the Prostigmata, including *O. stepheni* and *M. yemensis*, are cross-striated (Lindquist, 1996b). The muscle cells of the Eriophyoidea are unique, not found in other arthropods (Nuzzaci & Alberti, 1996), and appear to be smooth (Lindquist, 1996b; Nuzzaci & Alberti, 1996). Some authors regard it to be a sign of primitiveness, but Nuzzaci & Alberti (1996) proposed that the non-striated muscle cells most likely derived secondarily from cross-striated cells, possibly because of miniaturization.

### *4. Tonofibrillary muscle attachments – presence:

0 = present
1 = absent

Tonofibrillary muscle attachments are present in the Prostigmata, including *O. stepheni* and *M. yemensis*, but are absent in the Eriophyoidea (Lindquist, 1996b).

### *5. Basal membranes around organs, including salivary glands and central ganglion – presence:

0 = present
1 = absent

Basal membranes are present around organs, such as the salivary glands and central ganglion of the Prostigmata, including *O. stepheni* and *M. yemensis*, but are absent around the organs of the Eriophyoidea (Lindquist, 1996b).

## CHAETOTAXY

### *6. Compliment of setae in immatures:

0 = without all setae that are present in the adult
1 = with all setae that are present in the adult (except eugenital setae of male)

### ***7. Chemical composition of setae:

0 = setae without actinopilin
1 = setae with actinopilin, causing birefringence

F. Grandjean found that the majority of sensilli of the body and appendages in the Actinotrichida (to which the Prostigmata belong) are birefringent, an optical property, and this is due to a core or layer of anisotropic material termed actinopilin (Evans, 1992). Lindquist (1996b) argued that the presence of actinopilin in the setae of the Eriophyoidea, together with other character states, are evidence that the Eriophyoidea indeed belongs within the Acari, and particularly in the Actinotrichida. Actinopilin is present in all the species in the out- and ingroup of the present study. The character has been included in this character discussion, because it is regarded as important in the relationship of the Eriophyoidea with other arthropods and mites. Although it is not of use in studying the phylogeny of the taxa in this specific analysis, I regarded it as an important part of information to be added to the data matrix. The character states with similar evidence, including those listed by Lindquist (1996b), will be added to future data matrices expanding the matrix used in the present study.

## Gnathosomal setae

### 8. Gnathosomal palp seta *d* – presence and shape:

0 = present, simple (e.g., Fig. 3.35)
1 = present, simple and prominent
2 = present, forked (Fig. 3.68)
3 = present, minute
4 = absent

A simple gnathosomal palpgenual seta (*d*) (named *dg* in the Tydeidae by André, 1981a), is present on the palpfemorogenu of *O. stepheni* (Fig. 4.1). In *M. yemensis* a seta is present on the palpgenu (*personal observation*), but according to Lindquist (1985) only a posterolateral seta (*l''* PGe), and not a dorsal seta, occurs on the palpgenu of all Tetranychidae, and the state "palp *d* absent" was assigned to *M. yemensis*. Within the Eriophyoidea, palp *d* [previously known as the subapical (Keifer, 1959a), antapical (Keifer, 1975a), or rostral seta (Ramsay, 1958)] is the only seta present on the segment that Lindquist (1996a) regards as the consolidated palptrochanter-femur-genu (Fig. 3.23). Based on its dorsodistal position, Lindquist (1996a) postulated it to be the palpgenual seta *d*.

Palp *d* is simple and tapering in most Eriophyoidea species, and additionally very prominent in *Neophytoptus ocimae* and minute in *Neocupacarus flabelliferis*. In five species in the present study (*Dicrothrix anacardii*, *Euterpia fissa*, *Leipothrix solidaginis*, *Neodicrothrix tiliacorae* and *Porosus monosporae*) (Eriophyidae: Phyllocoptinae), palp *d* is forked (e.g., Fig. 3.68). In *Vimola syzygii*, (Diptilomiopidae: Diptilomiopinae) palp *d* is strongly turned upwards distally (descriptive drawing in Boczek & Chandrapatya, 1992a), but seemingly not with such a sharp corner that it can be regarded as a minute fork, as advised by Amrine (1996).

Particularly the shape of palp *d* is used in the classification and identification of the Eriophyoidea. Unfortunately, this seta is not routinely recorded, depicted and described in species descriptions, and this absence of published data renders it an ambiguous character for phylogenetic analyses if scored from published descriptions.

When palp *d* was recorded as present, but it was not depicted in the descriptive drawing (e.g., for *Paraciota tetracanthae*) (Mohanasundaram, 1984) the character state "present" was assigned and *vice versa*. When its presence was not described in the text and it was absent in the drawing [e.g., *Acarhis diospyrosis* (Chandrapatya & Boczek, 1991c) among many others], particularly found in earlier descriptions, the code "?" (unknown) was assigned. It was not regarded as absent, because the gnathosomal setae are generally not depicted, even when present.

The shape of palp *d* was determined from the text description and/or drawing, otherwise it is presumed the seta is simple if not otherwise recorded or depicted by the species author(s), because typically this seta is simple in the Eriophyoidea, and one can reasonably expect any other shape should have been recorded by the descriptor. The absence of palp *d* was not recorded for *Quintalitus squamosus* (Meyer, 1989c) and was determined on a SEM image of this species.

The character states scored for the following species, in particular, are ambiguous:

- *Cosella deleoni*, *Mackiella phoenicis* and *Diptilomiopus ficus* (Keifer, 1956; Keifer, 1939a; Attiah, 1967, respectively): presence of palp *d* was not recorded in the descriptive text, but a line or very short, vague line in the position where palp *d* is usually inserted, is an indication that it may be present, and character state "present" was assigned to these species;
- *Trisetacus pini*: although the presence of palp *d* was not recorded or depicted by Keifer (1963b) or Boczek (1969) it is presumed it is present and simple, similar to other known *Trisetacus* spp.;
- *Diptilomiopus camarae* and *Proneotegonotus antiquorae* (Mohanasundaram, 1981b; 1983a, respectively): palp *d* was described as thick; however, it was not depicted as such in the descriptive drawings. Character state "simple", without the inclusion of "thickness" as a state, was assigned to these species.

- *Acarhis diospyrosis* (Chandrapatya & Boczek, 1991c): palp *d* is absent in the drawing and not mentioned in the text. In this case *v* was depicted, and it is presumed the author would have depicted palp *d* if it was present. Character state "absent" was scored for this species.

It will be a better option to divide this character in future studies into at least two characters: palp *d* present or absent, and a second character to score the shape of the seta (including simple, simple and prominent, forked, and minute). The latter character can be further divided into length (e.g., long and minute) and shape (e.g., simple and forked). These options will increase "not applicable" scores, though.

***9. Solenidion on palptarsus – presence:**

0 = with solenidion $\omega$
1 = without solenidion $\omega$

Solenidion $\omega$ is almost consistently present on the palptarsus of Actinotrichida (Evans, 1992), and is also present on the palptarsus of *O. stepheni* (Fig. 4.1) and *M. yemensis* (Fig. 4.2), but it is absent in all Eriophyoidea species (Lindquist, 1996b).

## Prodorsal setae

A compliment of four setae (on one side of the body) (or in other words: present as four pairs one on each side of the body for each seta) (Fig. 3.3d) are present on the prodorsum in many families of Prostigmata mites (Lindquist, 1996a). The maximum number of prodorsal setae in the Eriophyoidea is five setae (*ve* and *sc*, and single *vi*) in the monotypic *Pentasetacus* (Schliesske, 1985). The characteristics of the prodorsal setae (Fig. 3.3) form an integral part of the Eriophyoidea classification. In particular the presence of the setae anteriorly on the prodorsum (single or paired *vi*, and *ve*) distinguishes the family Phytoptidae (Fig. 3.3e–i), in which some or all these setae are present, from the Eriophyidae and Diptilomiopidae where these setae are absent in all species (Fig. 3.3j, k).

Characters 10 and 11. Lindquist (1996a) hypothesized that the loss of both *vi* and *ve* may have occurred once, in the common ancestors of the Eriophyidae and Diptilomiopidae, and the loss of *vi* and *ve* individually may have occurred once each in the family Phytoptidae.

### 10. Seta *vi* – presence, single or paired and position:

0 = one pair present
1 = one seta *vi* absent, position of remaining seta shifted to anteromedian position
2 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 108, Character 1: 0 = present; 1 = absent).

In the present analysis, paired *vi* is present in *O. stepheni* (Fig. 4.1) (similar to the generalized Tydeidae of Hong & Zhang, 1996a). Within the Tetranychidae paired *vi* is always absent in Tetranychinae species (Lindquist, 1985), including *M. yemensis* (Fig. 4.2). It is present or absent in the Bryobinae, or is rarely represented by single *vi* anteromedially (Lindquist, 1985), similar to Eriophyoidea species in the Nalepellinae.

In the Eriophyoidea classification this character is of importance at the family level. It is present as one seta anteromedially (single *vi*) (Fig. 3.3a, e–g) in species of the Nalepellinae (of which eight species are included in the present 318-taxon data set). Amrine (1996) proposed that the pair of setae anteromedially on the prodorsum of *Prothrix aboula*, is paired *vi* (Fig. 3.3h), and created a new subfamily, Prothricinae, for this species. In the original description of this species Keifer (1965a) regarded this pair as *sc* that moved far forward. *Prothrix aboula* is included in the present analysis, and the interpretation of Amrine (1996) that paired *vi* is present, is followed for scoring the character in the data matrix.

### 11. Seta *ve* – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 109, Character 2: 0 = present; 1 = absent).

In the present analysis *ve* is present as a pair in *O. stepheni* (Fig. 4.1) and in *M. yemensis* (Fig. 4.2). When it is present, *ve* is always present as a pair (one seta on each side of the body) (Fig. 3.3d, e, h, i) in the Eriophyoidea. In the Eriophyoidea classification, most species of the Phytoptidae have *ve*, except Nalepellinae species, excluding *Pentasetacus*. In the present 318-taxon data set, 16 species with *ve* present are included. Seta *ve* is never present in the Eriophyidae or Diptilomiopidae.

### *12. Prodorsal seta *sce* (*sc2*) – presence:

0 = present
1 = absent

Seta *sce* is present as a pair in *O. stepheni* (Fig. 4.1) and in *M. yemensis* (Fig. 4.2), but is absent in all Eriophyoidea species.

> Characters 13-18 (*sc*): according to the hypothesis of Lindquist (1996a) the paired posterolateral setae on the prodorsal shield of the Eriophyoidea (previously known as prodorsal or dorsal setae) are one of the two pairs of scapular setae (*sc*) found in other Prostigmata mites. He postulated that they are probably the internal scapular setae (*sci* or *sc1*). For scoring character states in the present study, it is presumed *sc* in Eriophyoidea is homologous to *sci* in other Prostigmata mites. The presence, position of and direction in which *sc* is projected (Fig. 3.3b, c), are used to typify Eriophyoidea genera (e.g., *Eriophyes* and *Aceria*) and tribes (e.g., Eriophyini and Aceriini).

### 13. Seta *sc* in Eriophyoidea (seta *sci* in other Prostigmata species) – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 109, Character 4: 0 = present; 1 = absent).

Seta *sci* is present as a pair in *O. stepheni* (Fig. 4.1) and in *M. yemensis* (Fig. 4.2). In the Eriophyoidea *sc* may be present (always in a pair) or absent. Lindquist (1996a) proposed that *sc* was lost repeatedly and independently within the Eriophyoidea, at least twice in both the Phytoptidae and Diptilomiopidae, and at least four times in the Eriophyidae. Indeed, within the taxa of the Eriophyoidea classification, and among the species included in the present study, species with and without *sc* co-occur in all three families and in some subfamilies: in the Phytoptidae: Nalepellinae, Phytoptinae and Sierraphytoptinae; Eriophyidae: Cecidophyinae, Nothopodinae and Phyllocoptinae and Diptilomiopidae: Diptilomiopinae and Rhyncaphytoptinae, as well as in some tribes, e.g., Phytoptinae: Acaricalini; Nalepellinae: Trisetacini; Sierraphytoptinae: Mackiellini and Nothopodinae: Nothopodini. Seta *sc* is absent in all *Diptilomiopus* spp.

The character states scored for the following species, in particular, are ambiguous:

- *Acarhis diospyrosis* (Diptilomiopidae): *sc* is recorded in the text as being absent, but *sc* is clearly depicted (Chandrapatya & Boczek, 1991c), and the authors placed the species in *Acarhis* in which, by definition, *sc* is present, and character state "present" was scored for this species.
- In some species (e.g., in the new *Diptilomiopus* spp., Appendix M) *sc* may seem absent, but on closer inspection, a remnant of *sc* might be present.

### 14. Seta *sc* length:

0 = exceptionally long (> 100 µm)
1 = very long (66 – 100 µm)
2 = long (31 – 65 µm)
3 = average (4 – 30 µm)
4 = short (1 – 3 µm)
5 = minute (not measurable, less than 1 µm long)

Seta *sc* is 30 µm (*n* = 1) long in *O. stepheni* (character state "average" assigned) and 103 µm (*n* = 1) in *M. yemensis* (character state "exceptionally long" assigned) (C. Craemer, *personal observations*). In the Eriophyoidea the lengths vary from exceptionally long to minute, but most lengths are in the average category (length data approximate normal distribution).

The length of *sc* of *Fragariocoptes setiger* was not reported in the original description by Nalepa (1894) and neither later in the redescription by Roivainen (1951), but was reported in the redescription by Boczek (1964) from which the character state was scored.

The character states scored for the following species, in particular, are ambiguous:

- *Acarhis diospyrosis* (Diptilomiopidae): *sc* is recorded to be absent, but character state "present" is assigned (see explanation with previous character) and in the descriptive drawing (Chandrapatya & Boczek, 1991c) *sc* is depicted extremely short, barely noticeable, and I deduced that it is probably less than 3 µm long and character state "short" was scored for this species.
- The length of *sc* of *Konola hibernalis* (Keifer, 1979b), *Bucculacus kaweckii* (shield length 26 µm) (Boczek, 1961) and *Catachela machaerii* (shield length 40 µm) (Keifer, 1969b) were not recorded, but the species were all assigned character state "average" based on the relative length of *sc* to the prodorsal shield in their drawings.

### 15. Seta *sc* length relative to prodorsal shield length:

0 = exceptionally long (> three times shield length)
1 = very long (< three, but > or equal to 1.5 shield length)
2 = long (< 1.5, but > or equal to one shield length)
3 = average length (< one, but > 0.2 shield length)
4 = short (< or equal to 0.2, but > 0.07 shield length)
5 = very short (< or equal to 0.07 shield length)

A character similarly defined, but the ratio between different characteristics than in the present study, was used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 115, Character 33: 0 = very long (longer than the distance between two tubercles); 1 = long (longer than half the distance between two tubercles); 2 = short (shorter than half the distance between two tubercles); 3 = absent).

In the present study *sc* length in relation to prodorsal shield length is experimentally included, to standardize length of *sc* with body size (for future studies it might be better to rather score *sc* length in relation to body length, if relationships are included in the data set). It was also included to have a character similar to that of the one in the previous analyses for comparative reasons, and to increase the number of characters for the present analyses. However, it is inadvisable to use relational data in phylogenetic analyses, and this character should probably be omitted in future analyses and data matrices for the Eriophyoidea.

Seta *sc* is 30 µm ($n = 1$) long and the prodorsal shield 75 µm ($n = 1$) long in *O. stepheni* (character state “average” assigned) and 103 µm ($n = 1$) and the prodorsal shield 145 µm ($n = 1$) long in *M. yemensis* (character state “average” assigned).

*Fragariocoptes setiger*: the length of neither the prodorsal shield nor *sc* was reported in the original description by Nalepa (1894) and neither later in the redescription by Roivainen (1951), but they were reported in the redescription by Boczek (1964) from which the character state was scored.

The character states scored for the following species, in particular, are ambiguous:

- *Acarhis diospyrosis* (Diptilomiopidae): *sc* is described to be absent, but it was scored as “present” (see explanation for Character 13). The relationship of *sc* with the prodorsal shield could be determined from the descriptive drawing (Chandrapatya & Boczek, 1991c), and I deduced that *sc* is very short in comparison with the prodorsal shield length.
- *Heterotergum gossypii* (Keifer, 1955), *Monotrymacus quadrangulari* (Mohanasundaram, 1982a), *Notacaphylla chinensiae* (Mohanasundaram & Singh, 1988), *Tegonotus mangiferae*

(Keifer, 1946), *Neoacarhis aglaiae* (Kuang, 1998) and *Levonga caseariasis* (Chakrabarti & Pandit, 1996): prodorsal shield length of these species was not recorded, however, for the present study, it was measured and determined from the original descriptive drawings and *sc* was "short" in relation to the shield length for the latter two species.

- *Acaphyllisa parindiae* (Keifer, 1978), *Acarhis diospyrosis* (Chandrapatya & Boczek, 1991c) and *Catachela machaerii* (Keifer, 1969b): *sc* length was not recorded for these species, and relative length to prodorsal shield length was determined by measuring these on the descriptive drawing, because the measurement ratios are well within the categories short, very short and long, respectively.

### 16. Scapular setal tubercle (Fig. 3.3b, c) – presence:

0 = primarily absent
1 = present
2 = secondarily absent
3 = prominent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 109, Character 3: 0 = absent; 1 = present).

Setae of the Tenuipalpidae and the Tetranychidae are not usually, and particularly the setae of *O. stepheni* and *M. yemensis*, are not inserted on tubercles, with subsequent loss of the tubercles within the group. The absence of setal tubercles is regarded in these species as being "primarily absent" in the present study. In the Eriophyoidea most setae are usually inserted on tubercles and in some species a seta may be naturally absent (not broken off in specimens), while the setal tubercle is still present. For the present analysis it has been presumed *sc*, when it is present in the Eriophyoidea, is inserted on a setal tubercle. This may be ambiguous in some cases, but descriptive drawings and information generally are not detailed enough to determine the absence or presence of the setal tubercle when the seta is present.

The character states scored for the following species, in particular, are ambiguous:

- *Neolambella ligustri*: according to the original descriptive drawing (Lin & Kuang, 1997), it seems that the scapular setal tubercle is absent, and the species was assigned character state "absent" for the present study, but it may be present (there is a short diagonal line in the lateral area below the prodorsal shield pattern cells).
- *Prodiptilomiopus auriculatae*: the presence of scapular a setal tubercle is uncertain; character state "absent" is assigned to this species for the present study; structures depicted on the rear

shield margin (Umapathy & Mohanasundaram, 1999) may be tubercles, but they are not typical in the drawing.

- *Diptilomiopus* spp.: *sc* is always absent (the genus is currently defined as such), and according to Amrine *et al.* (2003) the scapular setal tubercle may be present or absent, within the genus. The presence of this tubercle is unknown for *D. javanicus*, the type species of *Diptilomiopus*, and the presence or absence of it in this species may have an influence on the definition and delimitation of *Diptilomiopus* and possibly whether *Vilaia* (it was wrongly differentiated from *Diptilomiopus* because it has the scapular setal tubercle present) may be regarded as a valid genus (Craemer *et al*., 2005). When the scapular setal tubercle is present in *Diptilomiopus* spp. it may be very small and can also be obscured by the ridges on the shield, and the presence in species for which it has been recorded as absent, is ambiguous and should be checked in future on type specimens if possible. Particularly the recorded absence for the following *Diptilomiopus* spp. may be ambiguous:
    - *championi* – structures, vaguely and obscurely visible in the scanning electron microscope image accompanying the original species description (Huang, 1992), may be the scapular setal tubercles;
    - *holopteleae* – depicted prodorsal shield (Abou-Awad & El-Banhawy, 1992) probably distorted and broken in this area, and determining the presence or absence of the scapular setal tubercle from the drawing is impossible;
    - *indicus* – Chakrabarti & Pandit (1996) recorded the absence of the scapular setal tubercle, but their drawing is too small to confirm;
    - *pocsi* – description and drawing (Farkas, 1967) generally in doubt;
    - and *ficus* – the presence or absence of the scapular setal tubercle was not described in the text, but structures which are probably these tubercles, are present in the drawing by Attiah (1967).

Characters 17 and 18. Position and direction of seta *sc*: In those Eriophyoidea species studied, with *sc* located on or near the rear shield margin in adults, directed posteriorly, this seta is located well ahead of the rear shield margin, and the seta is directed dorsoanteriorly in the larva. In the nymph of such species, *sc* generally is in a position and orientated intermediate between that of the larva and adult (Lindquist, 1996a). The larval state of *sc*, which may be retained in the adults of some species, was proposed to be ancestral or plesiomorphic by Lindquist (1996a) *a priori* phylogenetic analyses.

### 17. Seta *sc* and/or scapular setal tubercle position (Fig. 3.3b, c):

0 = ahead of rear shield margin (less than half of shield ahead)
1 = well ahead of rear shield margin (on half of shield or further anteriad)
2 = on rear shield margin, or slightly ahead of rear shield margin
3 = immediately caudad of rear shield margin

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 109, Character 7: 0 = ahead of rear margin; 1 = at the rear margin).

The character states scored for the following species, in particular, are ambiguous:

- *Lithocarus thomsoni*: in the descriptive drawing of the dorsal view (Chandrapatya & Boczek, 2000c) it seems that *sc* is on or close to half of the dorsal shield length, and in the lateral view drawing further than half the shield length ahead (thus possibly "well ahead"), however, according to the reported measurements of the distance of *sc* from the rear shield margin in relation to the prodorsal shield length, *sc* is only about a third of the prodorsal shield length ahead of the rear shield margin (assigned character state "ahead").
- *Pararhynacus photiniae*: the scapular setal tubercle is just ahead of the rear shield margin in the descriptive drawing (Kuang, 1986a), but its position could not be confirmed in the Chinese text. The depicted position could have been caused by the prodorsal shield pressed down and to the back by the slide-mounting process (assigned character state "on rear shield margin, or slightly ahead of rear shield margin").
- *Steopa bauhiniae*: Chandrapatya & Boczek (2001b) described *sc* to be close to the rear shield margin, and it is just ahead of the rear shield margin in the dorsal view drawing. In the lateral view drawing, however, it seems to be ahead of the rear shield margin, thus dorsally it may have been pushed closer to the rear shield margin by the weight of the cover slip (assigned character state "on rear shield margin, or slightly ahead of rear shield margin").

### 18. Seta sc – direction of projection (Fig. 3.3b, c):

0 = anteriad, diverging
1 = anteriad: parallel, converging or up (Fig. 3.3c)
2 = medially
3 = up and to the outside
4 = posteriad, usually diverging (Fig. 3.3b)
5 = posteriad, converging
6 = no particular direction (i.e., in any direction)

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 110, Character 8: 0 = forward; 1 = backward; 2 = upward or inward). They scored *sc* in Tydeidae as being directed forward. Seta *sci* of *O. stepheni* and of *M. yemensis* is not particularly directed in any direction (C. Craemer, *personal observations*). The direction in which *sc* of the Eriophyoidea is projected corresponds with the position and/or the shape of its setal tubercle, and these characteristics in combination are used to differentiate between suprageneric Eriophyoidea taxa, for example, between Eriophyini and Aceriini.

The character states scored for the following species, in particular, are ambiguous:

- Although *sc* of *Acathrix trymatus* is too short to determine exactly in which direction it might be extended, it seems plausible that it will rather extend slightly divergently anteriad, than converging or parallel anteriad, when extrapolating the direction from the scapular tubercle as it is depicted by Keifer (1962c).
- It sometimes seems that a longer *sc* might have been directed medially if it was shorter, but because it is longer, it is directed about medially and then "turn" more anteriad and eventually, towards the tip of the seta, it diverges (e.g., *Eriophyes quadrifidus* Meyer & Ueckermann, 1989a); these cases were assigned character state "anteriad, diverging".
- The direction into which *sc* is directed in *Fragariocoptes setiger* is described and depicted in the original description by Nalepa (1894) and in the redescription by Boczek (1964) as being directed up and centrad, however, in the redescription by Roivainen (1951), it is described as being directed up, and in the drawing it is depicted as being directed divergently posteriorly, Amrine *et al.* (2003) interprets the situation in the couplet leading to the genus as "prodorsal shield with *sc* directed divergently forward or posteriorly". For the present study it has been decided to assign polymorphic character states: directed up and possibly pushing down in any of three directions, either anteriad diverging, anteriad converging or posteriad. This is ambiguous, and the descriptions may be of different species.
- It is not possible to determine solely on the only descriptive drawing of the lateral view (Liro, 1943) of *Rhinophytoptus concinnus* exactly in which direction *sc* is directed. It is clearly projecting anteriad, but it could either be converging or diverging. The descriptive drawing of *R. dudichi* is used in Amrine *et al.* (2003) to depict *Rhinophytoptus* and in this species, *sc* is directed diverging anteriad. Extrapolating from this, for the present study, the character state "diverging anteriad" was scored for *R. concinnus.*

### Opisthosomal setae (Figs 3.2, 3.3a, 3.4)

Lindquist (1996a) homologized the setae found in the Eriophyoidea with that of other acariform mites. In the process, he also renamed them to the standard setal notation developed by F. Grandjean (references listed in Lindquist, 1996a). It is difficult to homologize the Eriophyoidea setae, especially the opisthosomal setae, with that of other acariform mites (Lindquist, 1996a). The absence of cupules (lyrifissures) – a series of segmental remnants reflecting the ancestral segmentation – in the Eriophyoidea, contributes to this problem. Lindquist (1996a) based the setal homologies on the sequential arrangement of muscle sets in the Eriophyoidea opisthosoma, and on the suppression of anamorphosis also found in other Prostigmata groups. He regarded all opisthosomal setae in the Eriophyoidea as fundamental setae according to the concepts of F. Grandjean (references listed in Lindquist, 1996a), because all setae are already present in the larval instar. The larva is the first active life stage in most Prostigmata and plesiomorphically its hysterosoma (opisthosoma in Eriophyoidea mites) may have six transverse segments, according to F. Grandjean's (references listed in Kethley, 1990; Lindquist, 1996a) system anterior to posterior: C, D, E, F and H, and a segment consisting of the valves encompassing the anus designated as PS (pseudoanal) (Kethley, 1990; Lindquist, 1996a). Segment PS is typically reduced in size and occupies a ventrocaudal position (Lindquist, 1996a). Although the setal homologies and names for setae in the Eriophyoidea proposed by Lindquist (1996a) are based on his extensive and well recognized knowledge and experience with the morphology of acariform mites, the homologies stay ambiguous until they are empirically tested. Opisthosomal *d*, *e* and *f* were not specified as specific pairs of these setae present in other acariform mites (Lindquist, 1996a), but only that they occur on these segments. Lindquist (1996a) proposed that they are probably lateral elements of the dorsal setae on these segments. The maximum number of opisthosomal setae (seven pairs) occurs only in some Phytoptidae, and only *f* and *h2* are present in all Eriophyoidea species.

**Table B.1.** Opisthosomal setae (Figs 3.2, 3.3a, 3.4) (except *c1* and *h1*) absent in Eriophyoidea species included in the present study. Setae *f* and *h2* are never absent in the Eriophyoidea. Only species, with at least one of the opisthosomal setae absent, are included in the table. Absence of a setal pair is ticked x.

| | | | *c2* | *d* | *e* |
|---|---|---|---|---|---|
| **Phytoptidae:** | | | | | |
| Prothricinae | | *Prothrix aboula* | | x | |
| Sierraphytoptinae: | Mackiellini: | *Retracrus johnstoni* | | x | |
| | Sierraphytoptini: | *Neopropilus jatrophus* | | x | x |
| **Eriophyidae:** | | | | | |
| Nothopodinae: | Nothopodini: | *Anothopoda johnstoni* | | | x |
| Eriophyinae: | Aceriini: | *Paraphytoptella arnaudi* | | | x |
| | | *Ramaculus mahoe* | | | x |
| | Eriophyini: | *Asetilobus hodgkinsi* | | | x |
| Cecidophyinae | Cecidophyini: | *Neserella decora* | | | x |
| Phyllocoptinae: | Acaricalini: | *Knorella gigantochloae* | | x | x |
| | | *Schizacea gynerii* | | x | x |
| | | *Tumescoptes trachycarpi* | | x | x |
| | Anthocoptini: | *Neomesalox kallarensis* | | x | |
| | Calacarini: | | | | |
| | Phyllocoptini: | *Acamina nolinae* | | x | x |
| | | *Cecidodectes euzonus* | | x | x |
| | | *Euterpia fissa* | | x | x |
| | | *Neocupacarus flabelliferis* | | x | x |
| | | *Neodicrothrix tiliacorae* | | x | x |
| | | *Proneotegonotus antiquorae* | | x | x |

| | | | *c2* | *d* | *e* |
|---|---|---|---|---|---|
| | | *Prophyllocoptes riveae* | | | x |
| | | *Tergilatus sparsus* | | | x |
| | Tegonotini: | *Dicrothrix anacardii* | | x | |
| Ashieldophyinae | | *Ashieldophyes pennadamensis* | | x | x |
| **Diptilomiopidae:** | | | | | |
| Diptilomiopinae: | | *Acarhis* spp. in the present study (3 spp.) | x | | |
| | | *Africus psydraxae* | x | | |
| | | *Dacundiopus stylosus* | x | | |
| | | *Davisella breitlowi* | x | | |
| | | *Diptilomiopus* spp. in the present study (86 spp.) | x | | |
| | | *Diptilorhynacus dioscoreae* | x | | |
| | | *Diptilorhynacus sinusetus* | x | x | |
| | | *Kaella flacourtiae* | x | | x |
| | | *Lambella cerina* | x | | |
| | | *Levonga* spp. in the present study (3 spp.) | x | | |
| | | *Lithocarus thomsoni* | x | | |
| | | *Mediugum sanasaii* | x | | x |
| | | *Neoacarhis aglaiae* | x | | |
| | | *Neodiptilomiopus vishakantai* | x | | |
| | | *Neorhynacus rajendrani* | x | | |
| | | *Norma lanyuensis* | x | | |
| | | *Prodiptilomiopus auriculatae* | x | | |
| | | *Rhynacus arctostaphyli* | x | | |
| | | *Steopa bauhiniae* | x | x | |
| | | *Suthamus chiangmi* | x | | |
| | | *Thailandus diospyrosae* | x | | x |
| | | *Vimola syzygii* | x | | |

Characters 19 and 20. Only *c1* and *c2* are present in the Tenuipalpidae (including in *O. stepheni*), named *d1* and *l1* by André (1981a) (Fig. 4.1). Setae *c1*, *c2* and *c3* are present in the Tetranychidae (Lindquist, 1985), and are also present in *M. yemensis* (Fig. 4.2). Setae *c3* are regarded as neotrichous (Lindquist, 1985).

### 19. Seta *c1* (Fig. 3.3a) – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 112, Character 12: 0 = present; 1 = absent).

The setae on the opisthosomal dorsum of the Tydeidae are very stable, and *c1* (named *d1* by André, 1981a) is present in all Tydeidae (André, 1981a) including *O. stepheni* (Fig. 4.1). Seta *c1* is present in all the instars of the Tetranychidae (Lindquist, 1985) including *M. yemensis* (Fig. 4.2). In the Eriophyoidea *c1* is only present in some members of the Phytoptidae, and absent in most Eriophyoidea species. It is significant in the Eriophyoidea classification at the subfamily and tribal level. Thirteen Eriophyoidea species with *c1* [resorting in the Nalepellinae (Trisetacini, Pentasetacini), Phytoptinae, Prothricinae and Sierraphytoptinae (Sierraphytoptini)] are included in the present study.

### 20. Seta *c2* (Figs 3.2, 3.4) – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 113, Character 25: 0 = present; 1 = absent).

The setae on the opisthosomal dorsum of the Tydeidae are very stable, and *c2* (named *l1* by André, 1981a) is present in all Tydeidae (André, 1981a) including *O. stepheni* (Fig. 4.1). Seta *c2* is present in all the instars of the Tetranychidae (Lindquist, 1985) including *M. yemensis* (Fig. 4.2).

Within the species included in the present analyses, *c2* is only absent in species of the Diptilomiopinae (12 genera with and 22 genera, including *Diptilomiopus*, without *c2*) (Table B.1). Outside the Diptilomiopinae, *c2* is absent in *Thacra piperasia* Keifer, 1978 (Eriophyidae: Phyllocoptinae: Tegonotini) (Keifer, 1978; Amrine *et al.*, 2003). This species is not included in the present study. Lindquist (1996a) also reported it to be absent in *Cecidodectes* and *Acamina*, but it is present in the type species of these two genera (Meyer & Ueckermann, 1989b; Keifer, 1939a, respectively).

### 21. Setal tubercle of seta *c2* – presence:

0 = primary absent
1 = present
2 = secondary absent

Seta *c2* is not inserted on a tubercle in *O. stepheni* (Fig. 4.1) nor in *M. yemensis* (Fig. 4.2). To indicate that this tubercle is not usually present, with subsequent loss within the group, absent in these species is termed “primary absent”. When *c2* is present in the Eriophyoidea, it is presumed, for the present study, it is inserted on a setal tubercle. This is generally the case for Eriophyoidea species, but hasn’t been studied or described *per se* in most species. Seta *c2* is absent in all *Diptilomiopus* spp., but in an unusual occurrence, *D. leeasis* was described with *c2* absent, but the setal tubercle of *c2* present (Chakrabarti *et al.*, 1992).

Characters 22 – 24 (seta *d*). A maximum of two pairs of setae (*d1* and *d2*) occur on the dorsal opisthosomal transverse region D in the Prostigmata (Kethley, 1990). Seta *d2* is lost in most families of Anystina, Eupodoidea, Tydeoidea, Bdelloidea, Caligonellidae, Raphignathidae, and all Heterostigmata (Kethley, 1990). Only *d1* (*d2* in André, 1981a) is present in the Tydeoidea in this region (André, 1981a; André & Fain, 2000), except *Australotydeus* in which *d2* (*l2* in André, 1981a) is also present (André, 1981a; André & Fain, 2000). According to Ueckermann & Grout (2007) *d1* and *d2* are present in *O. stepheni* (Fig. 4.1). According to their naming of the setae they effectively proposed that one or more setae *ps* are absent, and both *d2* and *e2* is present, which would be an unusual case for a member of the Tydeidae. With alternative interpretation of the dorsal opisthosomal setae (C. Craemer, present study), *d2* may be absent in *O. stepheni*, and the seta currently named *d2* might rather be *e1*, André (1981a) mentioned that *e1* (*d3*) is the only seta that may migrate, and tend to move to fill the gap following the disappearance of *d2* (*l2*) and *e2* (*l3*). He adds, though, that it never goes beyond lyrifissure *im* and thus *e1* (*d3*) is always positioned behind this lyrifissure. The apparent position of this seta *O. stepheni* is, however, in the transverse area D (above lyrifissure *im* and more in the lateral region), and is problematic. Another hypothesis that might explain the dorsal setae in *O. stepheni* is that all setae of *e*, *f* or *h* may be entirely absent, but this does not seem likely. Further study, especially of the type specimens, is necessary to resolve the comparative homology of these setae, but falls beyond the scope of the present study.

Setae *d1*, *d2* and *d3* can be present in the Tetranychidae, *d3* is regarded as being neotrichous (Lindquist, 1985) or in other words, is considered secondary (Kethley, 1990). Only *d1* and *d2* are present in *M. yemensis* (Fig. 4.2).

This discussion on setal homologies, names and positions in the Tydeidae is so detailed, because for the outcome of the analysis, it is important to know which pair of the *d*-setae is homologous with *d* found in the Eriophyoidea. For the present study it is presumed the seta *d* homologous to *d* in the Eriophyoidea is present in *O. stepheni* and *M. yemensis* (i.e., *d1* or *d2*). A similar argument should be true for other outgroups and other setae (opisthosomal *e* and *f*) with less than the usual full complement of paired setae present per segment, if the specific pair can not be denoted as homologous to the pair present in the Eriophyoidea. This reasoning almost is kin to creating a hypothetical outgroup, where it is presumed the specific dorsal pair of setae were present plesiomorphologically, and that loss thereof is derived, regardless whether the specific homologous pair of setae is indeed present in the outgroup species (be it a species from the Tydeidae, Tetranychidae or another Prostigmata group).

### 22. Seta *d* – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 112, Character 13: 0 = present; 1 = absent).

Among Eriophyoidea species included in the present study *d* is absent in species belonging to all three families (Table B.1): in the Phytoptidae the three species with *d* absent are all fusiform with similar body shapes. Within the Eriophyidae, *d* is absent in members of the Phyllocoptinae, and they are also fusiform mites usually with an exposed life style, and in *Ashieldophyes pennadamensis*, also with an exposed life style (it is a leaf vagrant), albeit with a more vermiform body shape. Within the Diptilomiopidae *d* is absent in two species of the Diptilomiopinae, neither of them vermiform. One of the species not included in the present study, but reportedly with *d* absent (Mohanasundaram, 1986b) is the phyllocoptine species, *Hemiscolocenus rares*. However, in the drawing of this species it seems that *e* might be absent, with *d* present. Amrine *et al.* (2003) erroneously stated in their key that all opisthosomal setae are present in the latter genus. At first glance, it seems that *d* is lost particularly in species with a more fusiform body shape and exposed life style, and may have been lost at least three times homoplastically to account for its absence in all three families, if the classification *sensu* Amrine *et al.* (2003) are natural.

Of the 17 species in the present study without *d*, only *d* of the opisthosomal setae (except *c1* and *h1* which may also be absent) is absent in four species, the remainder also have either *c2* (in diptilomiopine species) or *e* (Phytoptidae and Eriophyidae species) absent (Table B.1).

The character states scored for the following species, in particular, are ambiguous:

- *Pararhynacus photiniae*: the presence of *d* could not be determined [ventral view not depicted and it could not be scored from the Chinese description by Kuang (1986a)]. It is presumed *d* is present, because the author stated that the new genus and species are similar to *Rhynacus*, and *Rhynacus* possesses *d*.
- *Steopa bauhiniae*: *d* was recorded as absent, and it seems that *d* is indeed absent according to the descriptive drawing (Chandrapatya & Boczek, 2001b), however, according to the position

of the seta, there is also a possibility that rather *e* is absent, and the seta present, now denoted *e*, may be *d*.

### *23. Seta *d* – number of pairs:

0 = more than one pair present
1 = only one pair present

Regardless of the precise homology of opisthosomal *d* between the Tetranychidae and Eriophyoidea, two pairs of opisthosomal *d* is present in *M. yemensis* (Fig. 4.2), and only one pair of *d* is present in the Eriophyoidea. The state of "more than one pair present" for *O. stepheni* is ambiguous, though. As interpreted by Ueckermann & Grout (2007) two pairs of opisthosomal *d* are present in *O. stepheni* (Fig. 4.1), but if alternative setal homologies are considered (C. Craemer, present study), only one pair of *d* may be present, similar to most other Tydeidae, including the genera from which it was differentiated (see discussion of alternative setal homologies above). The code "?" (unknown) is assigned to *O. stepheni*.

### *24. Seta *d* – position:

0 = dorsally
1 = displaced ventrolaterally

All setae *d* occur dorsally on the opisthosoma of the Tydeidae including *O. stepheni* (Fig. 4.1), and Tetranychidae including *M. yemensis* (Fig. 4.2). In the Eriophyoidea *d* occurs ventrolaterally. Lindquist (1996a) proposed that the ventral opisthosomal setae in the Eriophyoidea are setae of dorsolateral origin in other Prostigmata that moved to a ventral position.

Characters 25 – 27 (seta *e*). A maximum of two pairs of setae (*e1* and *e2*) occur on the dorsal opisthosomal transverse region E in the Prostigmata (Kethley, 1990). Seta *e2* is lost in most families of Anystina, Eupodoidea, Tydeoidea, Bdelloidea, Caligonellidae, Raphignathidae, and all Heterostigmata (Kethley, 1990). Only *e1* (*d3* in André, 1981a) is present in the Tydeoidea on this region (André, 1981a), and André (1981a) additionally regarded the presence of only *e1* (*d3*) [without *e2* (*l3*)] as the situation in the "dorsal idiosomal paleotaxy" (plesiomorphic or primitive state) of the Tydeidae. According to Ueckermann & Grout (2007) *e1* and *e2* (lengths of these setae were given in the text) are present in *O. stepheni* (Fig. 4.1). They did not comment on the significance of this in the Tydeidae. See the discussion of the presence of *d2* and possible alternative setal homologies for *O. stepheni* above. Setae *e1*, *e2* and *e3* can be present in the Tetranychidae, *e3* is regarded as being neotrichous (Lindquist, 1985) or in other words, is considered secondary (Kethley, 1990). Only *e1* and *e2* are present in *M. yemensis* (Fig. 4.2).

### 25. Seta *e* – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 112, Character 14: 0 = present; 1 = absent).

Among Eriophyoidea species included in the present study, *e* is absent in species belonging to all three families (Table B.1). In the Phytoptidae, *e* is absent only in one species, *Neopropilus jatrophus*, and in this species, *d* is also absent (Huang, 1992). Within the Eriophyidae, *e* is absent in members of the Phyllocoptinae which are fusiform mites usually with an exposed life style, and in *Ashieldophyes pennadamensis*, also with an exposed life style (it is a leaf vagrant) (Mohanasundaram, 1984). In these species, *d* is usually also absent, except in two species of the Phyllocoptini, *Prophyllocoptes riveae* (Mohanasundaram, 1984) and *Tergilatus sparsus* (Meyer & Ueckermann, 1995) in which only *e* is absent. Different from Eriophyoidea species in which *d* is absent, *e* is also absent in members with a more vermiform body shape and mostly living a sequestered lifestyle in the Nothopodinae, Eriophyinae and Cecidophyinae (Table B.1). Only *e* (and not *c2* and *d*) is absent in these species. Within the Diptilomiopidae *e* is absent in three species of the Diptilomiopinae. In these three species *c2* is also absent (Table B.1).

The character states scored for the following species, in particular, are ambiguous:

- *Pararhynacus photiniae*: the presence of *e* could not be determined [ventral view not depicted and description by Kuang (1986a) in Chinese]. It is presumed *e* is present, because the authors stated that the new genus and species are similar to *Rhynacus*, and *Rhynacus* has *e* present.

### *26. Seta *e* – number of pairs:

0 = more than one pair present
1 = only one pair present

Regardless of the precise homology of opisthosomal *e* between the Tetranychidae and Eriophyoidea, two pairs of opisthosomal *e* are present in *M. yemensis* (Fig. 4.2), and only one pair of *e* is present in the Eriophyoidea.

The state of "more than one pair present" in the Tydeidae is ambiguous, though. As interpreted by Ueckermann & Grout (2007) two pairs of opisthosomal *e* are present in *O. stepheni* (Fig. 4.1), but if alternative setal homologies are considered, only one pair of *e* may be present in *O. stepheni*, similar to most other Tydeidae, including the genera from which it was differentiated or *e* may not even be present in *O. stepheni* (see discussion of alternative setal homologies above). The code "?" (unknown) is assigned to *O. stepheni*.

### ***27. Seta *e* – position:**

0 = dorsally
1 = displaced ventrolaterally

All setae *e* occur dorsally on the opisthosoma of the Tydeidae including *O. stepheni* (Fig. 4.1) and the Tetranychidae, including *M. yemensis* (Fig. 4.2). In the Eriophyoidea, they occur ventrolaterally. Lindquist (1996a) proposed that the ventral opisthosomal setae in the Eriophyoidea are setae of dorsolateral origin that have moved to a ventral position (similar to the situation for *d*).

### ***28. Seta *f* – number of pairs:**

0 = more than one pair present
1 = only one pair present

Setae *f1* and *f2* occur in the Prostigmata, but *f3* have been lost in all Prostigmata groups except in some Endeostigmata (Kethley, 1990). Regardless of the precise homology of opisthosomal *f* between the Tydeidae, Tetranychidae and Eriophyoidea, within the Tydeidae including *O. stepheni* (Fig. 4.1), and Tetranychidae including *M. yemensis* (Fig. 4.2), *f1* and *f2* (two setal pairs) are present. Seta *f* is never absent in the Eriophyoidea species known to date, but only one pair is present.

### ***29. Seta *f* – position:**

0 = dorsally
1 = displaced ventrolaterally

All setae *f* occur dorsally on the opisthosoma of the Tydeidae including *O. stepheni* (Fig. 4.1), and Tetranychidae including *M. yemensis* (Fig. 4.2). In the Eriophyoidea they occur ventrolaterally. Lindquist (1996a) proposed that the ventral opisthosomal setae in the Eriophyoidea are setae of dorsolateral origin that have moved to a ventral position.

### <u>30. Seta *h1* – presence and length:</u>

0 = present
1 = minute or dot-like (2 µm or less)
2 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 115, Character 31: 0 = present; 1 = absent).

Setae *h1*, *h2* and *h3* may occur in the Prostigmata and of these, *h1* and *h2* occur in the Tydeidae (Kethley, 1990). With the plausible scenarios of setae homologies and names in *O. stepheni*, including the interpretation by Ueckermann & Grout (2007) (Fig. 4.1), both *h1* and *h2* are present in *O. stepheni* and neither is minute nor dot-like. In the Tetranychidae *h1* (that may possibly alternatively be *f3*) and *h2* and *h3* may occur (Lindquist, 1985). Seta *h1* is inserted dorsally, but *h2* and *h3* are smaller and inserted ventrocaudally, and *h3* may be a neotrichous seta (Lindquist, 1985). Setae *h1*, *h2* and *h3* occur in *M. yemensis* (Fig. 4.2) and are not either minute or dot-like.

Within the Eriophyoidea, conventionally, the presence or absence of *h1* is sometimes used to differentiate between species, but has not been used at a supraspecific level. Sometimes the length of *h1* is described as minute or dot-like. Unfortunately, in several cases, such as in *Diptilomiopus*, *h1* was described as being present, without any indication of length. In about all the taxa (families, subfamilies and tribes) all three states of *h1* are present, without a particular obvious pattern, except in the Diptilomiopinae, including all *Diptilomiopus* spp., where most species either have a very short or minute *h1*, or *h1* is absent. In contrast, most species in the Phytoptidae have *h1* present and it is longer than 2 µm, except in *Prothrix aboula* Keifer, 1965 (Keifer, 1965a) and some species in the Sierraphytoptinae.

The character states scored for the following species, in particular, are ambiguous:

- *Asetadiptacus emiliae*: Carmona (1970) recorded *h1* to be absent, with only small tubercles present. For the present analyses it is presumed *h1* is present, but minute in this species.
- As mentioned, the length of *h1* of many species was not recorded, e.g., for *Mediugum sanasaii* (Huang, 2001d) and *Schizoempodium mesophyllincola* (Oldfield, Hunt & Gispert, 1998), or the length of *h1* was recorded, but not available for the present study e.g., *Neolambella ligustri* (Lin & Kuang, 1997). Seta *h1* in these cases was assigned character state “present”, but it may be “minute” for some of these species.
- *Prodiptilomiopus auriculatae* and *Sakthirhynchus canariae*: the presence or absence of *h1* was not recorded in the text (Umapathy & Mohanasundaram, 1999), however, these authors depicted and enlarged the lateral view of the caudum, and it is presumed they would have

depicted *h1* in these drawings if this seta was present, thus character state "absent" was scored for these two species for the present study.

### *31. Opisthosomal setae *ps* – presence:

0 = present
1 = absent

Setae *ps1*, *ps2* and *ps3* occur on the PS segment in the Prostigmata (Kethley, 1990). The *ps* series of setae are larval in origin. Some Prostigmata groups (Raphignathoidea, Cheyletoidea, Tetranychoidea, Eriophyoidea, Heterostigmata and Parasitengona) do not exhibit additions to the body chaetome beyond the larval *ps* series (Kethley, 1990).

André (1981a) proposed that only one pair of *ps* setae is present in the Tydeidae and these may be lost in some species. According to Kethley (1990) *ps1* and *ps2* occur in the Tydeidae. These are probably named *h1* and *h2* by André (1981a) in his interpretation of the setae. In *O. stepheni*, one pair of *ps* is regarded to be present, ventrally close to the anus (Ueckermann & Grout, 2007) (Fig. 4.1). Setae *ps*1, *ps*2 and *ps*3 occur in the Tetranychidae (Lindquist, 1985). Only *ps*1 and *ps*2 are present in *M. yemensis* (Fig. 4.2). Regardless of the precise homology of opisthosomal *ps* between the Tydeidae, and Tetranychidae, Lindquist (1996a) proposed that no *ps* setae are present in the Eriophyoidea.

## Setae on coxisternal plates (Figs 3.4, 3.5)

The plesiomorphic number of coxisternal setae (presented in formulae) in all Tydeidae, on each of legs I-II is 3-1, respectively: *1a*, *1b* and *1c* on coxisternum I and *2a* on coxisternum II (André, 1981a), and this is also the case in *O. stepheni* (Fig. 4.1). In the Tetranychidae, the podosomal venter bears three pairs of prominent simple setae, known as ventral or intercoxal setae, of which only the anterior pair, *1a*, inserted between the bases of legs I and II and the second or middle pair, *3a*, between the bases of legs III, (Lindquist, 1985) are of concern in determining primary homologies between the Tetranychidae and the Eriophyoidea. These two pairs are already present in the larvae of tetranychid species (Lindquist, 1985). Seta *2a* is absent. On the coxisternal plates themselves, the primitive and maximum number of coxisternal setae (presented in formulae) on each of legs I-II is 2-2, respectively (Lindquist, 1985): *1b* and *1c* on coxisternum I and *2b* and *2c* on coxisternum II. In *M. yemensis*, this full compliment of intercoxal and coxisternal setae is present (Fig. 4.2).

In the Eriophyoidea the coxisternal plates characteristically have two pairs of setae (*1a* and *1b*) inserted on plates I and 1 pair (*2b*) on plates II, thus written in formula (not conventionally done for the Eriophyoidea) coxisternal I – coxisternal II is (2-1), and this is also the maximum number of these setae in this superfamily. The homologies of these setae with those in other acariform mites and their names were proposed by Lindquist (1996a). The relative position of the setae on the coxisternal plates in comparison with each other, in the Eriophyoidea, is stable intra-specifically (Hong & Zhang, 1996a), and has been described by some Eriophyoidea taxonomists such as Meyer (1990a).

### **32. Seta *1b* – presence:**

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 112, Character 15: 0 = present; 1 = absent).

Seta *1b* is present in *O. stepheni* and in *M. yemensis* (Figs 4.1, 4.2, and also see discussion above). Seta *1b* is generally shorter and weaker than *1a* and *2a* in the Eriophyoidea, and has been lost in some species in each of most subfamilies of the Eriophyidae and Diptilomiopidae, but not in any of the members of the Phytoptidae. The absence of *1b* is important at the generic level in the Eriophyoidea. It is especially of importance in keying to the tribes of the Nothopodinae (present in the Colopodacini, but absent in the Nothopodini), and is prominent in keying to and differentiating genera and generic groupings in the Diptilomiopinae and Aceriini (Amrine *et al.*, 2003). According to the key by Amrine *et al.* (2003) and recent diagnoses of the genus, *1b* is absent in all species assigned to *Diptilomiopus*. The presence or absence of *1b* in the type species (*D. javanicus*) is, however, not known. Nalepa (1918) described the position of the second pair of coxal setae (*1a*) in this species as "*die Hüftborsten des zweiten Paares vor den inneren Hüftwinkeln sitzend*", but did not mention the presence or absence of *1b*.

The character states scored for the following species, in particular, are ambiguous:

- *Neolambella ligustri*: in the descriptive drawing (reproduced in Amrine *et al.*, 2003), *1b* seems to be present, but according to T. Stasny (*pers. comm.*) the lines are folds in the coxal surface, and that this was confirmed with the species authors. For the present study this character is scored "absent" for this species.

- *Diptilomiopus ervatamiae*: *1b* is present (Chandrapatya & Boczek, 1991a) in only this one species of *Diptilomiopus*. When compared with the position of *1b* in this species, the presumably *1a* in some of the other *Diptilomiopus* spp. (e.g., *D. alagarmalaiensis*, *D. knorri* and *D. pocsi*) is situated so far ahead of the rear coxisternal margin in comparison with the length of coxisternal plates I, and the anterior approximation between them, that the seta may possibly be rather *1b* than *1a*, and *1a* may be absent. This is particularly the case in *Suthamus chiangmi*. Chandrapatya & Boczek (2000a) interpreted it as being *1a* with *1b* absent in this species, however, and it has been assigned as such for the present study. If *D. ervatamiae* (with *1b* present and only the tubercles of *1a* remaining) and the situation in single other diptilomiopine species were not known, this alternative hypothesis would have been regarded as unlikely, since *1a* seems to be much more stable and more rarely absent than *1b*, and usually when *1b* is absent, *1a* is also absent (also see Lindquist, 1996a).

### 33. Setal tubercle of *1b* – presence:

0 = primary absent
1 = present
2 = secondary absent

Seta *1b* is not primarily inserted on tubercles in the Tydeidae, including *O. stepheni* (Fig. 4.1), and the Tetranychidae, including *M. yemensis* (Fig. 4.2), and therefore has been assigned the state "primary absent" in these two species in the present study. The presence, size and shape of the setal tubercle on which *1b* is inserted is usually not described for Eriophyoidea species, and with most descriptive drawings being semi-schematic or the morphology not depicted so precisely, these details could, in most instances, not be determined from the drawings. It has thus been presumed, whenever *1b* is present, it is inserted on a setal tubercle, and presence of *1b* denotes presence of setal tubercle *1b*.

### 34. Distance between setae *1b* in comparison with distance between setae *1a*:

0 = *1b* clearly further apart than *1a*
1 = *1b* slightly further apart than *1a*
2 = *1b* longitudinally in line with *1a*
3 = *1b* slightly closer together than *1a*
4 = *1b* clearly closer together than *1a*

Setae *1b* are clearly further apart than *1a* in *O. stepheni* (Fig. 4.1) and *M. yemensis* (Fig. 4.2). The relation of the distance between setae *1b* to the distance between setae *1a* in the Eriophyoidea is frequently not measured or described in the text, but can be easily determined from a descriptive drawing of this area. The distance between *1b* in comparison with the distance between *1a* ranges from further apart to closer in both the Eriophyidae and Phytoptidae, but in the Diptilomiopidae it generally seems to be further apart with only some species with states “slightly further” or “in line” or “slightly closer”. In none of the diptilomiopid species included in the present study are *1b* clearly closer together than *1a*. Within the Eriophyidae generally *1b* also rather seems to be further away or in line and sometimes closer, however, in the cecidophyine species included in the present study, *1b* mostly seems to be almost in line, in line or closer together than *1a* and never clearly further apart. Setae *1b* and *1a* usually seem in line or almost in line with each other in the Nalepellinae.

The assignment of character states for this character is subjective, and possible distortion of the coxisternal plates in slide-mounted specimens may cause the setae to be slightly pressed from their true position. Possible phylogenetic information in the character might additionally be obscured in the way the states were defined. The states where *1b* are slightly further or slightly closer together than *1a*, may be similar or the same as the setae being the same distance apart, or alternatively as being clearly further apart or closer together. Although the states are finely differentiated, they could be scored, and it was decided to experimentally keep the character states as they are for the present study. These relative positions of coxal setae to each other probably also inherently defines the shape of the coxae, and the latter may be a more realistic representation of these coxisternal plate characteristics.

### 35. Seta *1a* – presence:

0 = present
1 = absent

Seta *1a* is present in *O. stepheni* and in *M. yemensis* (Figs 4.1, 4.2), also see discussion above. Seta *1a*, in contrast to *1b*, is rarely absent in Eriophyoidea species. It is only absent in three species of the Diptilomiopinae: *Africus psydraxae*, *Diptilomiopus ervatamiae* and *Neodiptilomiopus vishakantai* (Meyer & Ueckermann, 1995; Chandrapatya & Boczek, 1991a; Mohanasundaram, 1982b, respectively). In *D. ervatamiae* the setal tubercle of *1a* is present, but *1a* is absent (*1b* is present in this species). This is quite an unusual state in the Eriophyoidea, since *1a* is rarely absent, and if absent, *1b* is absent as well (e.g., *A. psydraxae* and *N. vishakantai*). The absence of *1a* is autapomorphic for *D. ervatamiae* among *Diptilomiopus* spp. (also see discussion of Character 32).

The position of *1a* on the coxisternal plate may be of taxonomic and phylogenetic significance, but has not been scored in published descriptions. The variation of the position of *1a* from the rear proximal margin of coxisternal plate I was first noted in *Diptilomiopus* spp. in the present study. Seta *1a* of most *Diptilomiopus* spp. is situated quite close to the rear proximal margin of coxisternal plate I, and close to the approximation with coxisternal plate II. In some species, however, this seta is inserted quite clearly further away from this position (e.g., in *D. bengalensis*, *D. dendropanacis*, *D. euryae*, *D. holoptelus*, *D. indicus*, *D. malloti*, *D. phylanthi*, *D. septimus*). The difference in position can be compared between *D. holmesi* (close to rear margin) and *D. jevremovici* (further away from rear margin), both described by H.H. Keifer (Keifer, 1962c; Keifer, 1960, respectively). The position of *1a* on the coxisternal plate was scored for *Diptilomiopus* spp. in the present study, and subsequently for some of the species in other genera, where distinguishing between "close to" or "ahead of" became less obvious. It turned out that the position of *1a* may vary continuously, without discrete gaps, and defining the states and subsequent scoring and coding is highly subjective at this stage, and it was decided not to include this character in the present study. Based on the absence of *1a* and presence of *1b* in *D. ervatamiae* (albeit the tubercle of *1a* is still present in this species), some of the setae, named *1a*, more ahead of the basal margin of coxisternal plate I may rather be *1b* (also see discussion of Character 32).

### 36. Setal tubercle of *1a* – presence and shape:

0 = primary absent
1 = present and shaped as usual (about rounded or cylindrical)
2 = present and elongated
3 = secondary absent

Seta *1a* is plesiomorphically not inserted on a tubercle in the Tydeidae including *O. stepheni* (Fig. 4.1) and Tetranychidae, including *M. yemensis* (Fig. 4.2), and therefore has been assigned the state "primary absent" in these two species in the present study.

For scoring the character states of this character for the Eriophyoidea, it is presumed the shape of the tubercle is normal, except when specifically mentioned or depicted otherwise in the species description. The setal tubercle of *1a* is different from the usual more rounded or cylindrical shape in only two species. Both species are in the Diptilomiopinae and the tubercle is elongated in both: in *Diptilomiopus coreiae* it is described as being long, and it is depicted markedly longer than usually found in the Eriophyoidea, in the accompanied drawings (Chandrapatya & Boczek, 2002b). Among *Diptilomiopus* spp. long tubercle *1a* is autapomorphic for *D. coreiae*. It is also elongated in *Kaella flacourtiae* (Chandrapatya & Boczek, 2002b). Unfortunately, the shape of these tubercles in Eriophyoidea species has generally not been described, and differences in shape, if present, may be subtle, and the descriptive drawings are probably mostly not reliable or specific in this regard.

The character states scored for the following species, in particular, are ambiguous:

- Farkas (1967) described the tubercle of *Diptilomiopus pocsi* as being “well developed” and Boczek & Chandrapatya (2002) described the tubercles of all coxal setae in *D. thunbergiae* as being large. However, the tubercles of these species, as well as those of some other species for which the tubercle was depicted as large in their drawings (e.g., *D. knorri*, *D. pamithus*, *D. securinegus*, and *D. thaianae*), although possibly larger or more pronounced than “normal” do not constitute a distinctly different state when compared between descriptive drawings, and were scored as “shaped as usual”.

It will be a better option to divide this character in future studies into two characters: setal tubercle of *1a* present or absent, and a second character to score the shape of this tubercle, and for the latter character for those species with the setal tubercle absent, the score will be “not applicable”.

### **37. Seta *1a* – position:**

0 = ahead of *2a*
1 = slightly ahead of *2a*
2 = in line with *2a*
3 = slightly behind *2a*
4 = behind *2a*

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 115, Character 35: 0 = *1a* ahead of *2a*; 1 = *1a* same line as *2a*; 2 = *1a* behind *2a*).

Seta *1a* is clearly ahead of *2a* in *O. stepheni* (Fig. 4.1) and *2a* is absent in *M. yemensis* (Fig. 4.2), and “not applicable” was scored for the latter. Seta *1a* is ahead or slightly ahead of *2a* in the majority of the Eriophyoidea species included in the present study. In some of the species *1a* seems to be in line with *2a*, but this may be a consequence of schematic drawing, or the specimens may be slightly distorted due to slide-mounting, and these may also have *1a* slightly ahead of the *2a* or *vice versa*. Seta *1a* is slightly behind in three species [*Mackiella phoenicis*, *Propilus gentyi* (Sierraphytoptinae) and *Oziella yuccae* (Phytoptinae)] (Keifer, 1939a; 1975d; 1954, respectively) and clearly behind in two species [(*Novophytoptus rostratae* and *N. stipae* (Novophytoptinae)] (Roivainen, 1947l Keifer, 1962d, respectively), and all five species are in the Phytoptidae.

Similar to the distance between setae *1a* relative to the distance between setae *2a*, the character states are assigned subjectively, and the definition of states for this character may obscure phylogenetic information in the character, because it might have been defined into too many states with gaps between the states too small (e.g., slightly ahead, in line and slightly behind may essentially be the same character state). When studied carefully, the character states will probably vary into each other without clear gaps, and may be more accurately portrayed by using actual measurements (which can be analysed in TNT). The character is probably also very prone to body distortion in slide-mounted specimens, albeit it is usually quite stable, and can be assigned to one state within a sample of specimens, but this will probably vary according to the quality of mounting. It may be better to take the measurements on SEM images of specimens that are orientated the same and at the same angles, depending on the robustness of variation tolerated. The character does have potential as a phylogenetically informative character. It is currently regarded as rather a species level character.

### **38. Seta *2a* – presence:

0 = present
1 = absent

Seta *2a* is present in *O. stepheni* (Fig. 4.1) and is absent in *M. yemensis* (Fig. 4.2). The homologies of these setae when the Tenuipalpidae and Tetranychidae are compared, may be suspect, and there is a possibility that *2a* may also be absent in the Tydeidae. Seta *2a* is present in all Eriophyoidea species included in the present study, except in *Neocupacarus flabelliferis* (Das & Chakrabarti, 1985) (Eriophyidae: Phyllocoptinae: Phyllocoptini), and its absence is thus autapomorphic for this species within the Eriophyoidea in the present study. Setae *1a* and *1b* are present in this species.

The character state scored for the following species, in particular, is ambiguous:

- *Diptilomiopus javanicus*: although the presence of *2a* has not been explicitly recorded by Nalepa (1916, 1918), most Eriophyoidea species, and all diptilomiopid species have these setae present, thus state "present" was scored for this species.

## Setae associated with genitalia

Characters 39 – 42 are autapomorphic for the Eriophyoidea in the present analysis.

### *39. Genital setae in adult – presence:

0 = present
1 = absent

The maximum number of genital setae in the Tydeidae is six pairs but they are reduced or lost in some species (André, 1981a). Genital setae are not present in the larva of the Tydeidae, and is completely absent in tydeids of the Pronematinae (André, 1981a). Four pairs of genital setae are present in the females and males of *O. stepheni* (Ueckermann & Grout, 2007). There are two pairs of genital setae in the females of the Tetranychidae (Lindquist, 1985) including *M. yemensis* (Fig. 4.2). No genital seta is present in the adults of the Eriophyoidea. The pair of setae flanking the posterior area of the external genitalia of females, males and all immatures, and termed the genital setae (*sensu* H.H. Keifer), rather represents the pair of coxisternal, or intercoxal setae, *3a* (Lindquist, 1996a) (Figs 3.4, 3.5).

### *40. Aggenital setae in adult – presence:

0 = present
1 = absent

The maximum number of aggenital setae in the Tydeidae is five pairs but is reduced in some species (André, 1981a). Some aggenital setae are already present in the larva of the Tydeidae (André, 1981a). Four pairs of aggenital setae are present in the males and females of *O. stepheni* (Ueckermann & Grout, 2007). Adult males and females of the Tetranychidae usually have one pair of aggenital setae, and one pair of aggenital setae is present in *M. yemensis* (Fig. 4.2). Aggenital setae are always absent in the Eriophyoidea.

> Characters 41 and 42 (eugenital setae). Within the Actinotrichida eugenital setae are usually present in the adults of the Endeostigmata, a group considered most primitive of this superorder (Evans, 1992). Within the Eupodina, a suborder of the Prostigmata, eugenital setae may be present or absent (Evans, 1992).
>
> The eugenital setae may be present and are eupathidia, and the maximum number is six pairs in the Eupodina (André, 1981a). The number is greatly reduced in most Tydeidae and they are always smaller in females than in males (André, 1981a). The female of *O. stepheni* do not have eugenital setae, and four pairs are present in the male (Ueckermann & Grout, 2007). Eugenital setae are absent in the Raphignatina, a suborder of the Prostigmata, which include the Tetranychidae (Evans, 1992) and also when extrapolated, in *M. yemensis*. In all Eriophyoidea species eugenital setae are absent in the females, and one pair of minute eugenital setae is present in the males (Lindquist, 1996a).

### ***41. Eugenital setae in female – presence:

0 = present
1 = absent

Eugenital setae are absent in the females of all species (including *O. stepheni* and *M. yemensis*) included in the present study (see discussion above).

### *42. Eugenital setae in male – presence and number of pairs:

0 = more than one pair present
1 = one pair of minute setae present
2 = absent

Four pairs of eugenital setae are present in the male of *O. stepheni* (Ueckermann & Grout, 2007), also see discussion above. No eugenital setae are present in the male of *M. yemensis* (see discussion above). One pair of minute eugenital setae is present in the males of possibly all Eriophyoidea species, but this need to be confirmed by further study (see discussion above).

## Leg setae (Fig. 3.6a, b)

The leg cheatotaxy and ontogeny thereof are not generally described or recorded in detail in the description of tetranychid species, and have also not been described for *M. yemensis*, apart from the setal formula presented recording the number of setae, solenidia and duplicate setae on each segment of each leg (Meyer, 1996), and neither were the legs depicted. It falls beyond the scope of the present study and knowledge of the author to determine homology and to name each of the leg setae in *M. yemensis* from available specimens, and because Lindquist (1996a) homologized the leg setae in the Eriophyoidea with the basic setae (already present in the larva) of the Tetranychidae, and these should rarely be lost in the adults, the leg setae as depicted and named for a general adult female tetranychine spider mite in Lindquist (1985) have been used as if it is the leg setae present in *M. yemensis*.

**Table B.2.** Leg setae (except coxisternal setae) which are absent in Eriophyoidea species included in the data set. Where there are more than one species in a genus, only one species was included in the table, or if variation occur between species from the same genus, all such species with different absent setae were included. Only species with some leg setae absent are listed. Absence of a setal pair is ticked with x. Setae *bv* 1 is the seta on the femur of leg I, and *bv* 2 is the seta on the femur of leg II, likewise *l''* 1 is the seta on genu of leg I, and l'' 2 is the seta on genu of leg II. Seta *l'* is the seta on the tibia of leg I, and *ft'* 2 is seta *ft'* on the tarsus of leg II.

| | | | *bv* 1 | *bv* 2 | *l''* 1 | *l''* 2 | *l'* | *ft'* 2 |
|---|---|---|---|---|---|---|---|---|
| **Phytoptidae:** | | | | | | | | |
| Nalepellinae | Trisetacini | *Boczekella laricis* | | | | | x | |
| Novophytoptinae | | *Novophytoptus* spp. in the present study (2) | x | x | | | | |
| Prothricinae | | *Prothrix aboula* | | | | | x | |
| Sierraphytoptinae: | Mackiellini: | *Palmiphytoptus oculatus* | | | | | x | |
| | | *Propilus gentyi* | | | | | x | |
| | | *Retracrus johnstoni* | | | x | x | | |
| | Sierraphytoptini: | *Neopropilus jatrophus* | | | | | x | |
| **Eriophyidae:** | | | | | | | | |
| Aberoptinae | | *Aberoptus samoae* | | | | | x | |
| | | *Cisaberoptus kenyae* | | | | | x | |
| Nothopodinae: | Nothopodini: | *Anothopoda johnstoni* | | | | | x | |
| | | *Cosella deleoni* | | | | | x | |
| | | *Disella ilicis* | | | | | x | |
| | | *Floracarus calonyctionis* | | | | | x | |
| | | *Neocosella ichnocarpae* | | | | | x | |
| | | *Nothopoda rapaneae* | | | | | x | |
| | | *Pangacarus grisalis* | x | | | | x | |
| | Colopodacini | *Adenocolus psydraxi* | x | | | | x | |
| | | *Apontella bravaisiae* | x | | | | x | |
| | | *Colopodacus africanus* | | | | | x | |
| Eriophyinae: | Aceriini: | *Acalitus ledi* | x | | | | x | |
| | | *Cenaca syzygioidis* | x | | | | x | |
| | | *Cymoptus spiniventris* | | | | | x | |
| | | *Notaceria tetrandiae* | | | | | x | x |
| | | *Ramaculus mahoe* | | | | | x | |
| | Diphytoptini | *Diphytoptus nephroideus* | | | | x | | |
| | Eriophyini: | *Nacerimina gutierrezi* | | | | x | | |
| Cecidophyinae | Cecidophyini: | *Dechela epelis* | | | | x | x | |
| | | *Neserella decora* | | | | | x | |
| | Colomerini | *Afromerus florinoxus* | | | | | x | |
| | | *Cosetacus camelliae* | | | | | x | |
| | | *Epicecidophyes clerodendris* | | | | x | | |
| Phyllocoptinae: | Acaricalini: | *Cymeda zealandica* | | | | | x | |
| | | *Knorella gigantochloae* | x | x | | x | | |
| | | *Litaculus khandus* | | | | x | | |
| | | *Neodichopelmus samoanus* | | | | | x | |
| | | *Notacaphylla chinensiae* | | | | | x | |
| | | *Paracaphylla streblae* | x | x | | | | |
| | | *Schizacea gynerii* | x | x | | x | | |
| | | *Tumescoptes trachycarpi* | x | x | | x | | |
| | Anthocoptini: | *Catachella machaerii* | x | | | | x | |
| | | *Neocolopodacus mitragynae* | | | | | x | |
| | | *Nothacus tuberculatus* | x | | | | x | |
| | | *Notostrix attenuata* | | | | x | | |
| | | *Paraciota tetracanthae* | x | x | | x | x | |
| | | *Quintalitus squamosus* | x | | | | x | |

| | | | *bv* 1 | *bv* 2 | *l’’* 1 | *l’’* 2 | *l’* | *ft’* 2 |
|---|---|---|---|---|---|---|---|---|
| | | *Sinacus erythrophlei* | | | | | x | |
| | Calacarini: | *Calacarus pulviferus* | | | | x | | |
| | | *Jutarus benjaminae* | | | | x | | |
| | | *Paracalacarus podocarpi* | x | x | | x | | |
| | Phyllocoptini: | *Acamina nolinae* | x | x | | | | |
| | | *Arectus bidwillius* | x | | | | | |
| | | *Euterpia fissa* | x | x | | | | |
| | | *Indonotolox sudarsani* | | | | | x | |
| | | *Leipothrix solidaginis* | x | x | | | | |
| | | *Neocupacarus flabelliferis* | x | x | | | | |
| | | *Neodicrothrix tiliacorae* | | | | x | x | |
| | | *Neophytoptus ocimae* | x | x | | | | |
| | | *Proneotegonotus antiquorae* | | | | x | x | |
| | | *Prophyllocoptes riveae* | | | | | | |
| | | *Tergilatus sparsus* | | | | | | |
| | Tegonotini: | *Dicrothrix anacardii* | | | | | | |
| Ashieldophyinae | | *Ashieldophyes pennadamensis* | | | | | | |
| **Diptilomiopidae:** | | | | | | | | |
| Diptilomiopinae: | | *Acarhis* spp. in the present study (2) | x | x | x | x | | |
| | | *Acarhis diospyrosis* | x | x | x | x | x | |
| | | *Acarhynchus filamentus* | x | | | | | |
| | | *Africus psydraxae* | x | x | x | x | x | x |
| | | *Apodiptacus cordiformis* | x | x | | | | |
| | | *Asetadiptacus emiliae* | x | x | | | | |
| | | *Chiangmaia longifolii* | x | x | | | x | |
| | | *Dacundiopus stylosus* | x | x | | x | x | |
| | | *Davisella breitlowi* | x | x | | x | | |
| | | *Dialox stellatus* | x | | | | | |
| | | *Diptacus pandanus* | x | | | | | |
| | | *Diptacus sacramentae* | x | x | | | | |
| | | 24 of *Diptilomiopus* spp. in the present study* | x | x | x | x | x | |
| | | 54** of *Diptilomiopus* spp. in the present study* | x | x | x | x | x | x |
| | | *Diptilomiopus artocarpae* | x | x | | x | | |
| | | *Diptilomiopus azadirachtae* | x | x | | x | | x |
| | | *Diptilomiopus bengalensis* | ? | | | x | | |
| | | *Diptilomiopus cuminis* Huang | x | x | x | x | | |
| | | *Diptilomiopus guajavae* | x | x | | x | | x |
| | | *Diptilomiopus thangaveli* | x | x | | x | | x |
| | | *Diptilomiopus ulmivagrans* | x | x | | x | | |
| | | *Diptiloplatus megagrastis* | x | | | x | | |
| | | *Diptilorhynacus sinusetus* | x | x | x | x | x | |
| | | *Diptilorhynacus dioscoreae* | x | x | x | x | x | x |
| | | *Diptilostatus nudipalpus* | x | x | | x | x | |
| | | *Duabangus chiangmai* | x | x | | | x | |
| | | *Kaella flacourtiae* | x | x | | x | x | |
| | | *Lambella cerina* | x | x | x | x | x | |
| | | *Levonga* spp. in the present study (2) | x | x | | x | x | |
| | | *Levonga litseae* | x | x | | x | x | x |
| | | *Lithocarus thomsoni* | x | x | x | x | x | |
| | | *Mediugum sanasaii* | x | x | x | x | x | |

|  |  | *bv* 1 | *bv* 2 | *l''* 1 | *l''* 2 | *l'* | *ft'* 2 |
|---|---|---|---|---|---|---|---|
|  | *Neoacarhis aglaiae* | x | x |  | x | x |  |
|  | *Neodialox palmyrae* | x |  |  |  |  |  |
|  | *Neodiptilomiopus vishakantai* | x | x |  | x | x |  |
|  | *Neolambella ligustri* | x | x | x | x | x |  |
|  | *Neorhynacus rajendrani* | x | x |  | x |  |  |
|  | *Norma lanyuensis* |  | x |  | x | x |  |
|  | *Pararhynacus photiniae* | x | x |  |  |  |  |
|  | *Prodiptilomiopus auriculatae* | x | x | x | x | x |  |
|  | *Rhynacus arctostaphyli* | x | x |  | x |  |  |
|  | *Steopa bauhiniae* | x | x |  | x | x |  |
|  | *Suthamus chiangmi* | x | x | x | x |  |  |
|  | *Thailandus diospyrosae* | x |  | x | x | x |  |
|  | *Trimeroptes eleyrodiformis* | x | x |  |  |  |  |
|  | *Vimola syzygii* | x | x |  | x | x |  |
| Rhyncaphytoptinae | *Areekulus eugeniae* | x | x |  | x |  | x |
|  | *Asetacus madronae* | x | x |  |  |  |  |
|  | *Catarhinus tricholaenae* | x |  |  |  |  |  |
|  | *Chakrabartiella ficusis* | x | x |  |  |  |  |
|  | *Hoderus roseus* | x | x |  | x |  |  |
|  | *Konola hibernalis* | x | x |  |  |  |  |
|  | *Neocatarhinus bambusae* | x |  |  | x |  |  |
|  | *Quadriporca mangiferae* | x | x |  |  |  |  |
|  | *Sakthirhynchus canariae* | x | x | x | x | x |  |

* *D. championi* excluded – presence of *bv* on femur I and II, *l''* on genu I and II, *l'* on tibia, and *ft'* on tarsus II unknown.
** *D. pocsi* and *D. sandorici* – presence of *l'* unknown.

### 43. Leg I: seta *bv* (Fig. 3.6a, b) – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 112, Character 16: 0 = present; 1 = absent).

Seta *bv* originally belonged to the more basal of the two femoral segments of the legs in more plesiomorphic acariform mites, and it is the only ventral fundamental seta found on the femora of legs I and II in acariform mites (Lindquist, 1996a). Lindquist (1996a) proposed that the ventral femoral seta in the Eriophyoidea is homologous with seta *bv* in acariform mites.

In the Tydeidae the maximum number of setae occurring on femur I and II respectively is six and four, and the minimum on these two segments is two on each (André, 1981b). The proximoventral seta, *pv*, in the Tydeidae is amongst the strongest setae on the leg femur of legs I and II (André, 1981b). The position of this seta on the femur is similar to that of *bv''* in the Tetranychidae and represents the fundamental seta *bv* in acariform mites. This seta is present in *O. stepheni* (C.

Craemer, own observation). The femur in legs I and II in the larval and protonymphal instars of the Tetranychidae have three setae of which one is seta *bv''*, a seta in a proximoventral position, homologous to the fundamental seta *bv* in acariform mites. Seta *bv''* is present in legs I and II of adult females of the Tetranychidae (Lindquist, 1985), and is also regarded to be present in *M. yemensis.*

Seta *bv* on femur I is present or absent in Eriophyoidea species (Table B.2). Among species in the present study it is absent in some species in all three families. In the Phytoptidae it is absent in the two *Novophytoptus* spp. (Novophytoptinae). In the Eriophyidae it is absent in relatively few (five) species: of the Nothopodinae (three species) and Eriophyinae (two species in the Aceriini), and *bv* on femur II is not absent in any of these. In the Phyllocoptinae, with more exposed living forms, *bv* on femur I is absent in several species of most tribes of this subfamily, and frequently this seta on femur II is also absent in these species. Within the Diptilomiopidae, *bv* on femur I is absent in all species of the Diptilomiopinae, except in two species not belonging to *Diptilomiopus*, and two *Diptilomiopus* spp. for which the presence is unknown. Within the Rhyncaphytoptinae about half of the species are with and the other half without *bv* on femur I. In the majority of Diptilomiopidae species, *bv* on femur II is also absent when *bv* on femur I is absent.

The character state scored for the following species, in particular, is ambiguous:

- *Pararhynacus photiniae*: the presence of *bv* on femur I could not be determined [ventral view not depicted and text description by Kuang (1986a) in Chinese]. It is presumed *bv* is absent, because the authors stated that the new genus and species is similar to *Rhynacus*, and this seta is absent in *Rhynacus*.

### 44. Leg I: seta *l''* (Fig. 3.6a, b) – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 112, Character 17: 0 = present; 1 = absent).

The maximum number of setae on the genua of the Tydeidae is four. There is no other reference point on this segment to evaluate the setae, and there is no variation during ontogeny, and determining the homology of these setae with setae on this segment in the acariform mites is difficult and ambiguous (André, 1981b). The number of setae on genu I in the Tydeidae ranges from four to one (André, 1981b). Three setae are present on genu I of *O. stepheni* (Ueckermann &

Grout, 2007), and based on the setal positions in comparison with the labeled setae on leg I of *Meyerella marshalli* (André, 1980), *l''* are present, as well as *v'* and *l'* (Fig. 4.1).

In the larva and protonymph of the Tetranychidae, four setae is the standard number of setae on genua I and II, namely *l'*, *l''*, *v'*, and *v''*, and in the Tetranychinae *d* is added on genua I and II in the deutonymphs (Lindquist, 1985) and in the tetranychine adults these five setae are present (Lindquist, 1985). Seta *l''* is part of the basic larval-protonymphal complement, and it is not conceivable that it will be lost in *M. yemensis*, and it is extrapolated for the present study that *l''* is present on genu I of *M. yemensis*.

In the Eriophyoidea *l''* on the genu may be present or absent (Table B.2). Among the species included in the present study, it is present in all Phytoptidae [apart from *Retracrus johnstoni* (Sierraphytoptinae) where seta *l''* is absent from genu I and II (Keifer, 1965c)] and Eriophyidae, and is only absent in members of the Diptilomiopidae, and particularly of the Diptilomiopinae [among the Rhyncaphytoptinae it is only absent in *Sakthirhynchus canariae* (Umapathy & Mohanasundaram, 1999)]. Within the Diptilomiopinae it is absent in all *Diptilomiopus* spp. and in species of about 11 other Diptilomiopinae genera. Seta *l''* of genu I is present in some species currently in *Diptilomiopus* (*D. artocarpae*, *D. azadirachtae*, *D. guajavae*, *D. thangaveli* and *D. ulmivagrans*) (Mohanasundaram, 1981b; Boczek & Chandrapatya, 1992b; Mohanasundaram, 1985; 1983c; 1984, respectively), but these species should probably not be in *Diptilomiopus*. Seta *l''* on genu I is much more stable, and is lost in less species than *l''* on genu II. In species in the present study, *l''* is also absent from genu II when it is absent from genu I (Table B.2).

The character states scored for the following species, in particular, are ambiguous:

- *Diptilomiopus azadirachtae*: the presence of *l''* in leg I is ambiguous. Its presence is not mentioned in the text by Boczek & Chandrapatya (1992b), and the drawing seems to be wrong: the legs are depicted with 4 segments (excluding coxae), but the way the setae are positioned, it seems that the tibia may be absent, and not the genu. The segment proximally of the tarsal segment is relatively long, with a very strong seta (similar to a genual seta in other Eriophyoidea species). This can not be the tibia, firstly because in the text it is explicitly mentioned that the tibial seta *l'* is absent, and the seta is much longer and stronger than what seta *l'* usually is. The depiction of the second pair of legs has the same mistakes as the first leg, and the tibia of leg II never has a seta in the Eriophyoidea, and a similar strong seta is depicted dorsally on the segment just proximal of the tarsus. The most plausible explanation is that the genua (and *l''*) are present in this species, and that the distal margin of the tibiae was not depicted, creating a "tibiotarsus". There is an unusually long space basally of *ft'* and *ft''*. Seta *l''* was scored as present, however, this score is ambiguous.

- The presence or absence of *l''* in *Diptilomiopus* spp. is not described in the text or reliably depicted in the drawings in many cases, however, if the absence of genu I is clearly described or depicted, it is presumed *l''* is also absent, if not mentioned or depicted otherwise. This decision is supported by the definition of *Diptilomiopus* with *l''* absent and leg I and II, and presumably authors should not have assigned species to *Diptilomiopus* if it was otherwise.

### 45. Leg I: seta *l'* (Lindquist, 1996a) or *l* (proposed in the present study, for future investigation) (Fig. 3.6a, b) – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 113, Character 18: 0 = present; 1 = absent).

The hypothesized plesiomorphic setal compliment on the tibia of the Tydeidae includes five setiferous setae (*d*, *l'*, *l''*, *v'* and *v''*) of which one may be eupathidial, a famulus *k''* and solenidion *φ* (André, 1981b). In *Tydeus*, a genus relatively closely related to *Orfareptydeus*, only three setiferous setae are present on tibia I, and these are *l'*, *l''*, and *v'*; seta *l''* moved into the position of *d* (André, 1981b). Similar only these three setae are present on tibia I in *O. stepheni* (Fig. 4.1). Within the Pronematinae of the Tydeidae most species also have only three setae, *l'*, *l''*, and *v'*, in the case of these species though, *l'* moved into the position of the absent *d* (André, 1981b). The latter setal arrangement is not proposed for *O. stepheni* in the present study.

In the Eriophyoidea a single tibial setiferous seta may be present dorsally on tibia I, and tibia II is always without any setae. Lindquist (1996a) compared this seta with the tibial setae in the Tydeidae, and came to a conclusion that it may either be *d* or *l'*, but because *l'* is more stable than *d* in the Tydeidae, (*d* is replaced by *l'* in tibia II of the Tydeidae [*sic*]), he proposed that the tibial seta in the Eriophyoidea is seta *l'*. He commented, though, that the homology of this seta is problematic. One should, however, rather compare tibiae I with each other, than tibia I with tibia II. As discussed above, *d* may be lost and replaced by either seta *l'* or seta *l''* in tibia I of the Tydeidae (André, 1981b). In some Eriophyoidea species the tibial seta is displaced to the inner (paraxial) aspect of the tibia, and this may possibly indicate that the tibial seta is rather *l'*, however, in some other species it is displaced to the outer (antaxial) aspect of the tibia, and an argument can be made that this may indicate that the tibial seta is rather *l''*. In the present study the name *l' sensu* Lindquist (1996a) is still used, but I propose that the tibial seta in the Eriophyoidea may be homologous to a lateral seta (*l*), but that it can not be denoted as being the antaxial (*l''*) or paraxial (*l'*) lateral seta. This may have implications for determining primary homologies between the Eriophyoidea and other mite groups.

In the larva and protonymph of the Tetranychidae the basic setation of tibia I is five setae (*d*, *l'*, *l''*, *v'*, *v''*) and one solenidion (Lindquist, 1985). The setae on tibia I of adults of the Tetranychinae are not very variable and are 9 setae, and one solenidion *φ*, with addition of setae to the basic setation (Lindquist, 1985). It is extrapolated for the present study that *l'* and *l''* is present on the tibia of *M. yemensis*.

Seta *l'* can be present or absent in the Eriophyoidea (Table B.2). It is absent in a wide variety of taxa from all three Eriophyoidea families. In the Phytoptidae it is absent in members of the Nalepellinae, Prothricinae and Sierraphytoptinae. In the Eriophyoidea it is absent in all members of the Aberoptinae and Nothopodinae, partly defining these two subfamilies, but it is also widely absent in the Eriophyinae, Cecidophyinae and Phyllocoptinae. In the Diptilomiopidae it is absent in most members, including most *Diptilomiopus* spp., but within the Rhyncaphytoptinae it is absent in only *Sakthirhynchus canariae* (Umapathy & Mohanasundaram, 1999).

The character states scored for the following species, in particular, are ambiguous:

- *Boczekella laricis*: the presence of *l'* is not recorded, however, this seta is absent in the descriptive drawing of the species (Farkas, 1965a) and because the *l'* is normally depicted when present, it is presumed *l'* is absent, for the present study.
- *Scoletoptus duvernoiae*: *l'* is recorded as being absent in the original description (Meyer, 1992a), however, on close inspection this seta seems to be present. It is extremely fine and not clearly visible. The specimens available for study were in bad condition and additional newly collected specimens will have to be studied to confirm the presence of these setae. The character state "present" is scored for this species in the present study.

### **46. Leg I: seta *l'* – position:**

0 = dorsal on tibia
1 = displaced to the inner (paraxial) side of tibia
2 = displaced to the outer (antaxial) side of tibia

If it is assumed that the tibial seta in the Eriophyoidea is either seta *d*, or one of the lateral setae that shifted to the dorsal position originally occupied by the absent seta *d*. The position of these setae is dorsally on the tibia of both *O. stepheni* (Fig. 4.1) and *M. yemensis* (see discussion of Character 45 above). For determining the position of the seta homologous to the tibial seta in the Eriophyoidea in other mite groups, it becomes very important to determine the real homology of the seta, and in having trouble doing so, it renders the character ambiguous. Several scenarios are possible in which the state for the character in the outgroup taxa, may either be dorsal or lateral (paraxial or antaxial), depending whether the tibial seta *l'* (as denoted by Lindquist, 1996a) represents *d*, *l'*, or *l''* in the outgroup taxa.

In the Eriophyoidea, when *l'* is present, it is usually inserted dorsally on the tibia. Among species included in the present study, *l'* is positioned on the paraxial aspect of the tibia in the Diptilomiopidae (Diptilomiopinae: *Dialox stellatus*, *Diptiloplatus megagrastis* and *Neodialox palmyrae*, and Rhyncaphytoptinae: *Areekulus eugeniae* and *Cheiracus sulcatus*) (Keifer, 1962d; 1975c; Mohanasundaram, 1983b; Boczek & Chandrapatya, 1998; Keifer, 1977a, respectively). In the Phyllocoptinae it is positioned on the paraxial aspect in the Anthocoptini (*Ditrymacus athiasella*), and in the Tegonotini (*Dicrothrix anacardii*) (Keifer, 1960; 1966c, respectively), and on the antaxial or outer aspect of three species: *Hyborhinus kalarensis* (Rhyncaphytoptinae) (Mohanasundaram, 1986) and *Acaphyllisa parindiae* and *Neoacaphyllisa lithocarpi* (Phyllocoptinae: Acaricalini) (Keifer, 1978; Kuang & Hong, 1989, respectively).

The character states scored for the following species, in particular, are ambiguous:

- *Areekulus eugeniae*: it clearly seems as if *l'* is on the paraxial side of the tibia in the descriptive drawing (Boczek & Chandrapatya, 1998), however, this displacement is not mentioned in the descriptive text. For the present study the character state “displaced to the inner side of tibia” is assigned to this species, but it may be based on a drawing error.
- *Acarhynchus filamentus*: particularly in the enlarged drawing of the legs, it seems that *l'* might either be on the paraxial or antaxial aspects of the tibia (Keifer, 1959b), however, this is not mentioned in the text, and the character state “dorsal on tibia” was assigned to this species for the present study.
- *Hyborhinus kallarensis*: it clearly seems as if *l'* is on the antaxial side of the tibia in the drawing (depending on the aspect of the drawing facing towards the reader), however, this is not mentioned in the descriptive text of Mohanasundaram (1986). For the present study the character state “displaced to the outer side of tibia” is assigned to this species, but it may be based on a drawing error.
- *Neoacaphyllisa lithocarpi*: Kuang & Hong (1989) described *l'* as being on the mesal surface of the tibia. This might indicate that the seta is on the inner or “middle” surface of the tibia, but in

the drawing it seems that it might be on the antaxial or outer aspect of the tibia, and because this species is reportedly close to *Acaphyllisa*, in which this seta is inserted on the antaxial aspect, the state "displaced to the outer side of the tibia" is assigned to this species for the present study.

### 47. Leg I: seta *l'* – vertical position:

0 = near apical (distal) margin (less than quarter tibial length from distal margin)
1 = at about distal quarter
2 = at distal third
3 = on about middle (half) of tibia
4 = at basal third
5 = at basal quarter
6 = near proximal (basal) margin (less than a quarter from basal margin)

In *O. stepheni* (Fig. 4.1) and *M. yemensis* the tibial seta in the position of seta *l'* and *d* respectively is on the distal half of the tibia. In this case it is very important to determine the real homology of the setae, and in having trouble doing so, it renders the character ambiguous. In the Eriophyoidea the position of *l'* along the length of the tibial segment varies from near the apical (distal) margin to near the proximal (basal) margin of the segment. The states are probably too finely divided, but it was not clear where the division between different states should be. In future, real distances from one of the margins should be used. Apart from determining this position from the descriptive drawings, it is also frequently described in the text. The text description of this character got priority in the present study. In the few Diptilomiopinae species where *l'* is present, it is mostly inserted on the distal half of the tibia with single species with the seta on the basal third. Within the Rhyncaphytoptinae it is present in varying positions along the tibial length, but mostly at the basal third, and even near the basal margin. In the majority of Eriophyidae in the present study *l'* is on about the middle of the tibia (half) and on the basal half. It is in the distal half only in a few single species, except in the Phyllocoptini where it is in the distal half for slightly more species (eight species). Within the Phytoptidae, the position is more in the middle and in the distal half within the Nalepellinae, and in the remainder of the Phytoptidae it tends to be more in the middle and in the basal half of the tibia.

### 48. Leg I: tibial solenidion $\varphi$ – presence and position:

0 = present, about mid-tibial antaxial position
1 = present, in ventrodistal position
2 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 113, Character 22: 0 = present; 1 = absent). Hong & Zhang (1996a) erroneously scored this solenidion to be present in their general Tydeidae, however, it is absent in some species, such as *O. stepheni* (Ueckermann & Grout, 2007).

The hypothetical plesiomorphic condition or archetype of the Tydeidae includes only one solenidion on tibia I, namely solenidion *φ* (André, 1981b). No solenidion is present on tibia I of *O. stepheni* (Ueckermann & Grout, 2007) (Fig. 4.1). In larval and protonymphal Tetranychidae and eventually in adults of the Tetranychinae, similarly, only one solenidion, solenidion *φ*, is present on tibia I of females, however, more solenidia may be added on tibia I of males after the protonymphal stage (Lindquist, 1985). The solenidion in these species is inserted on the antaxial side of the tibia, about in the middle of the tibia.

Lindquist (1996a) proposed that the solenidion sometimes present on the tibia of Eriophyoidea mites represents solenidion *φ*, but commented that a fundamental solenidion in this almost ventral position is not present in any other Acariformes. The tibial solenidion *φ* in the Eriophyoidea is inserted ventrally and apically (distally) on the tibia. This solenidion is present only in the Phytoptidae, and in most members of all the subfamilies, except the Novophytoptinae, where it is absent in all members.

### 49. Leg I: tarsal solenidion *ω* – position:

0 = antaxial, about distal third of tarsus
1 = dorsal, about mid-tarsus
2 = dorsal, close to and above empodium
3 = lateral, close to empodium, on outer side of tarsus
4 = lateral, close to empodium, on inner side of tarsus
5 = ventrad of empodium

The hypothetical plesiomorphic condition or archetype of the Tydeidae includes only one solenidion on tarsus I, namely solenidion *ω* (André, 1981b). Solenidion *ω* is present about middorsally on tarsus I of *O. stepheni* (Ueckermann & Grout, 2007) (Fig. 4.1). In larval and protonymphal Tetranychidae generally only one solenidion, solenidion *ω''*, is present on tarsus I, and is autapomorphic for the Tetranychidae within the Tetranychoidea in its position closely beside seta *ft''*, to form a set of “duplex setae” (Lindquist, 1985). In the Tetranychinae three tarsal solenidia is present on tarsus I of females (Lindquist, 1985). Solenidion *ω''* is already present in the larva, and is thus the basic seta, and *ω* in the Eriophyoidea probably represents *ω''* in the Tetranychidae. Solenidion *ω''* is in a more antaxial position on the tarsus slightly distally of the middle of the tarsus (Lindquist, 1985).

Immature instars and adults of all Eriophyoidea species have a prominent solenidion, *ω*, on the tarsus of legs I and II, which is usually slightly curved, but may also be straight, and frequently is slightly enlarged apically to form a knob-like apical end. Within the Eriophyoidea the tarsal solenidion *ω* is usually inserted apically and dorsally, very close to and dorsal of the empodium. Within the following species included in the present study, it is inserted in another position: in one species, *Notaceria tetrandriae* (Eriophyinae: Aceriini) it is inserted dorsally, but proximally of the middle of the tarsus, and away from the empodium (Mohanasundaram & Muniappan, 1990), more similar to the position of solenidion *ω* in *O. stepheni*, than the other positions here recorded. In three species, *Aberoptus samoae* (Eriophyidae: Aberoptinae) and *Brevulacus reticulatus* and *Catarhinus tricholaenae* (Diptilomiopidae: Rhyncaphytoptinae), tarsal solenidion *ω* is inserted close to, but laterad (antaxial) of the empodium (Keifer, 1951; Manson, 1984a; Keifer, 1959b, respectively). In five species, *Cosella deleoni*, *Disella ilicis*, *Floracarus calonyctionis* and *Neocosella ichnocarpae* all from the Nothopodinae, and *Neocolopodacus mitragynae* in the Phyllocoptinae, tarsal solenidion *ω* is inserted close to, but laterad (paraxial) of the empodium (Keifer, 1956; 1965a; 1953; Mohanasundaram, 1981d; 1980, respectively). In two species, *Catachela machaerii* (Phyllocoptinae) and *Dechela epelis* (Cecidophyinae), tarsal solenidion *ω* is inserted close to, but ventrad of the empodium (Keifer, 1969b; 1965a, respectively).

### **50. Leg II: seta *bv* (Fig. 3.6a, b) – presence:**

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 113, Character 19: 0 = present; 1 = absent).

The homology of *bv* on femur II and presence thereof in the Tydeidae including *O. stepheni* and in the Tetranychidae including *M. yemensis*, is similar to the homology for *bv* on femur I presented above, and it is present in *O. stepheni* and *M. yemensis*. Seta *bv* on femur II is present or absent in the Eriophyoidea (Table B.2). Among the Eriophyoidea species in the present study the loss of *bv* on femur II follows about the same pattern as the loss of *bv* on femur I, and they are absent in some species in all three families. Mostly when *bv* on femur I is lost, *bv* on femur II is also absent, and this is the case in species of the Novophytoptinae (Phytoptidae), Phyllocoptinae (Eriophyidae) and Diptilomiopidae. In the Nothopodinae and Eriophyinae *bv* is absent on femur I in only a few species, and in these *bv* on femur II is still present.

The character state scored for the following species, in particular, is ambiguous:

- *Pararhynacus photiniae*: the presence of *bv* on femur II could not be determined [ventral view not depicted and description by Kuang (1986a) in Chinese]. It is presumed this seta is absent, because the authors stated that the new genus and species are similar to *Rhynacus*, and seta *bv* is absent on femur II of *Rhynacus*.

### 51. Leg II: seta *l''* (Fig. 3.6a, b) – presence:

0 = present
1 = absent

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 113, Character 20: 0 = present; 1 = absent).

Determining the homology of genual setae in the Tydeidae with setae on this segment in the Acariformes mites is difficult and ambiguous (André, 1981b, and see treatise of *l''* on genu I above). The number of setae on genu II in the Tydeidae ranges from four to none (André, 1981b). Two setae are present on genu II of *O. stepheni* (Ueckermann & Grout, 2007), and based on the setal positions in comparison with the labeled setae on leg I of *Meyerella marshalli* (André, 1980), *v'* and *l'* are present, with *l''* absent (Fig. 4.1). In Tetranychinae adults five setae are present on genu II (similar to genu I – also see discussion of *l''* on genu I above): *l'*, *l''*, *v'*, *v''* and *d* (Lindquist, 1985). By extrapolation these (and especially seta *l''* being one of the basic larval-protonymphal setae) are also present on genu II of *M. yemensis*.

In the Eriophyoidea *l''* on genu II may be present or absent (Table B.2). Among the species included in the present study *l''* on genu II is less stable, and is lost in more species in a wider range of taxa than *l''* on genu I. Seta *l''* is sometimes absent from genu I when it is absent from genu II, but in many species only *l''* on genu II is absent (Table B.2). Similar to *l''* on genu I, this seta on genu II is absent in a relatively large group of the Diptilomiopidae: in the Diptilomiopinae it is absent in all *Diptilomiopus* spp. and in species of about half of the remaining genera, and in the Rhyncaphytoptinae it is absent in four genera. It further is absent in one species of the Phytoptidae, *Retracrus johnstoni* (Sierraphytoptinae), where *l''* is absent from genu I and II (Keifer, 1965c). Seta *l''* on genu I is not absent in any of the Eriophyidae included in the present study, but *l''* on genu II is absent in some species in the Eriophyinae (*Diphytoptus nephroideus* and *Nacerimina gutierrezi*), in the Cecidophyinae (*Dechela epelis*) (Huang, 1991; Keifer 1979a; 1965a, respectively) and several species and genera in the Phyllocoptinae.

The character state scored for the following species, in particular, is ambiguous:

- *Areekulus eugeniae*: *l''* on genu II is absent in the descriptive drawing, but its absence was not mentioned in the descriptive text by Boczek & Chandrapatya (1998). It was scored "present" in the present study.

**<u>52. Leg II: seta *ft'* (Fig. 3.6a, b) – presence:</u>**

0 = present
1 = absent

The homologies of setae on the tarsi of adult Tydeidae are easy to establish, because each setiform structure retains a fixed position (André, 1981b). Seta *ft'* and *ft''* are present in the setal compliment of tarsus I and II of the Tydeidae (André, 1981b), and both setae are present in *O. stepheni* (Ueckermann & Grout, 2007) (Fig. 4.1). Setae *ft'* and *ft''* are also present in the basic tarsal setation of tarsus I and II of the Tetranychidae, and in their adults *ft'* and *ft''* may be closely associated with *ω'* and *ω''* respectively to form duplex setae (Lindquist, 1985). It is extrapolated that *ft'* and *ft''* are present on tarsus I and II of *M. yemensis*.

In the Eriophyoidea the presence of *ft'* on tarsus II is rarely recorded in the descriptive text, however, whenever it was missing in the descriptive drawing, and if the drawing could be trusted to be reasonably accurate, it was scored as "absent", in order to increase the information of this character in the present study by reducing unknowns (Table B.2). I suspect that this seta may be absent in many *Diptilomiopus* spp. and it may be of use in recovering clades within *Diptilomiopus*, or should at least be part of the diagnosis of the genus.

The character states scored for the following species, in particular, are ambiguous:

- *Neolambella ligustri* and *Areekulus eugeniae*: ft' is absent in the descriptive drawings (Lin & Kuang, 1997; Boczek & Chandrapatya, 1998, respectively) and the state "absent" was scored for these species, but the accuracy of the drawings is not certain and absence was not recorded in the descriptive text. This is the situation in most of the *Diptilomiopus* spp.

## <u>GNATHOSOMA</u>

Presence of unique gnathosomal autapomorphies for the Eriophyoidea in comparison with all Acari and as evidence for the hypothesized monophyly of the Eriophyoidea are listed by Lindquist (1996b) and these are included as Characters 53–56.

### *53. Gnathosomal stylets – presence of infracapitular (auxiliary) stylets:

0 = without a pair of styletlike structures (infracapitular stylets) additional to and flanking styletlike chelicerae
1 = with a pair of styletlike structures (infracapitular stylets) additional to and flanking styletlike chelicerae

The infracapitular (auxiliary) stylets are flanking the cheliceral stylets ventrolaterally in all Eriophyoidea and they appear to channel secretions from salivary glands (Keifer, 1975a; Lindquist, 1996a; Nuzzaci & Alberti, 1996). Determining the homology of the infracapitular stylets with gnathosomal structures in other non-Eriophyoidea mites are problematic (Lindquist, 1996a). Similar stylets do not appear in any non-Eriophyoidea species, including *O. stepheni* and *M. yemensis*, and their presence was listed by Lindquist (1996b) as a unique autapomorphy for the Eriophyoidea in comparison with all Acari and he proposed it as evidence for the monophyly of the Eriophyoidea.

### *54. Motivator between cheliceral bases – presence:

0 = not with a motivator between the cheliceral bases activating movement of cheliceral digits
1 = with a motivator between the cheliceral bases activating movement of cheliceral digits

A small knob or motivator lies between the cheliceral bases of the Eriophyoidea and activates alternate back-and-forth boring motions of the cheliceral stylets during feeding (Keifer, 1975a; Lindquist, 1996a; Nuzzaci & Alberti, 1996). The motivator is a structure unique (autapomorphic) to this superfamily (Lindquist, 1996b), and a homologous structure is absent in non-Eriophyoidea species, including *O. stepheni* and *M. yemensis*.

### *55. Apical ends of palpi – structure:

0 = palp-claw complex
1 = simple and linear
2 = blunt and truncated

The palpi, including the apical ends, are simple and linear in the Tydeidae (André, 1981a; Evans, 1992) and likewise in *O. stepheni* (Fig. 4.1). In the Tetranychidae (including *M. yemensis*) the two distal palp segments are modified into a palp-claw complex, with an enlarged tibial seta which forms a terminal claw-like structure and a tarsus displaced to a ventral position relative to the tibia (Evans, 1992). Distally the palpi of the Eriophyoidea are blunt and truncated with a disc-like lip facilitating an adhesive function (Fig. 3.19).

### *56. Palpi – shape:

0 = free limb-like appendages somewhat below and flanking the chelicerae
1 = enfolding and supporting the cheliceral and other gnathosomal stylets

The palpi of most Acari are free limb-like appendages (Evans, 1992). In the Eriophyoidea they are enfolding and supporting the gnathosomal stylets (Nuzzaci, 1979), which is an autapomorphic character state for the Eriophyoidea (Lindquist, 1996b).

### 57. Modification of palp apical ends – presence:

0 = not spatulate and without triangular projections
1 = strengthened, spatulate or with triangular projections

The apical segments of the palpi of the proposed deutogyne females of *Cisaberoptus kenyae* are fused, strengthened and spatulate (Keifer, 1966c). Likewise the distal ends of the palpi of the proposed deutogyne females of *C. pretoriensis* are strengthened with triangular projections (Meyer, 1989a). Amrine *et al*. (2003) strongly proposed that the deutogyne form of the female should not influence the generic concepts of the Eriophyoidea, and they synonymized *Cisaberoptus* with *Aceria*. Including and scoring the morphology of deutogyne females in the data sets of the present study is not strictly correct. Only protogyne females of the other Eriophyoidea species were included, and thus the same form of the females are not compared. However, these projections and strengthening of the palpi are unique for these two species, and didn't influence the retrieval of relationships for other species in the analyses, apart from potentially retrieving these two species as being closely related, as well as their relationships with other Eriophyoidea species in the analyses.

### 58. Gnathosoma, oral stylet form:

0 = short form (Fig. 3.22a)
1 = long form (Fig. 3.22b)

All Diptilomiopidae species have the long form oral stylet, and this may be a synapomorphy for this family (Lindquist & Amrine, 1996). The character is very clearly demarcated and easily distinguishable in specimens, and published descriptive data of this character are probably in general not ambiguous.

### 59. Gnathosoma, cheliceral shape:

0 = greatly elongated, strongly recurved basally within a stylophore, deeply retractable
1 = relatively straight and short in comparison with palpi (Figs 3.2a, 3.22a)
2 = abruptly bent down near base and relatively long in comparison with palpi (Figs 3.2b, 3.22b)

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 110, Character 10: 0 = evenly curved; 1 = abruptly curved). They scored the Tydeidae as having evenly curved chelicerae.

This character has the same character state distribution in the Eriophyoidea than the oral stylet form, but it is an entirely separate part of a complex of gnathosomal structures. If the gnathosoma is studied in more detail, both morphologically and anatomically, a suite of characters, which may not necessarily be linked, may be found and may have phylogenetic signal (also see the comparative morphological study of the gnathosoma in Chapter 3). The movable digits of the Tydeidae chelicerae are stylet-like (Nuzzaci & Di Palma, 2002) and mostly straight and shorter than the palpi, and although their detail morphological structures were not homologized with the same structures in the Eriophyoidea for the present study, they are broadly morphologically more similar than to those of the Tetranychidae. The chelicerae of the Tetranychidae are very different from those of the Eriophyoidea and the Tydeidae, consisting of relatively greatly elongated chelicerae with the bases fused to form a stylophore within which the cheliceral stylets can retract (Lindquist, 1985).

## PRODORSUM

### Prodorsal shield

**60. Prodorsal shield shape:**

0 = prodorsal shield almost absent
1 = broadly oval (shorter than wide)
2 = triangular or subtriangular, sometimes with rounded sides or more semicircular
3 = subtriangular with bulging sides
4 = subtriangular and broad
5 = inverted subtriangular
6 = circular or subcircular
7 = diamond-shaped
8 = subquadrate
9 = sub-rectangular
a = elongate oval
b = elongate triangular
c = with a prominent transverse division
d = roughly pentagonal
e = broadly T-shaped
f = about mushroom-shaped (e.g., *Cisaberoptus kenyae*)

The prodorsum of the Eriophyoidea is always covered or partly covered by a prodorsal shield. The shield shape can be broadly divided into being subcircular or subtriangular. The prodorsal shield shape varies more than these two states, and a more variable character state definition could be constructed. The species could be scored fairly accurately, but it was difficult to define primary homologies between the shapes. The prodorsal shield shape is usually described or depicted in species descriptions, and sometimes used in the classification and differentiation of species. It is not a very reliable and accurate character, however, because the states are delineated and determined subjectively, and it may additionally be influenced by distortion caused by slide-mounting. In particular it is not always clear whether the shape of the frontal lobe also influences the evaluation of the shield shape (see descriptions of *Diptilomiopus* spp.). The character is included in the present study, because it is usually described, and sometimes used to differentiate genera.

The number of character states was restricted to 16 in the present study (the default setting in TNT). Sometimes additional character states may improve the delimitation of character states, for example for this character, the state "no shield present on the prodorsum" would have been more accurate for coding the outgroup species than the state "prodorsal shield almost absent" scored for the outgroup species as well as for *Ashieldophyes* in the present study. The character states for this character should be improved in future studies, either by increasing or decreasing states, or redefining the character and the character states entirely.

The character states scored for the following species, in particular, are ambiguous:

- *Davisella breitlowi*: the shield shape was scored code "?" (unknown), because the measurements of the shield is given as 35 µm long and 70 µm wide (twice as wide as long), but in the drawing the shield seems to be as long as, or slightly longer than wide (Davis, 1964a).
- *Neoacaphyllisa lithocarpi* and *Dicrothrix anacardii*: although there is a unique extension at the rear margin of the prodorsal shield of *N. lithocarpi* (Kuang & Hong, 1989), the shape of the anterior or "main" part of the prodorsal shield is subtriangular, and the character state "subtriangular" was assigned. The rear extension can be regarded as a separate character, but it was not scored for the present analysis because it is autapomorphic for *N. lithocarpi*, and would not be informative for retrieving relationships between Eriophyoidea taxa in the analyses. Similarly the shape of the prodorsal shield of *D. anacardii* was assigned character state "semi-circular" despite an extensive extension at the rear shield margin (Keifer, 1966c).
- *Keiferella juniperici*: the character state "subtriangular" was assigned, despite a deeply convex (towards the posterior end) rounded rear shield margin (Boczek, 1964). A similar shape is also

present in other species and was assigned as such. These states should be re-evaluated and probably re-scored.

**61. Ocelli or ocellar-like areas on the prodorsal shield – presence, number and shape:**

0 = present, two well delineated ocelli on each side
1 = absent, or not visible on surface cuticle
2 = present, one or two ocellar-like areas laterally on prodorsal shield

The primitive number of ocelli on the prosoma of the Actinotrichida is three pairs (Evans, 1992). Two pairs of lateral ocelli are frequently present in the Prostigmata (Evans, 1992), and in the Tetranychidae (including *M. yemensis*) two pairs of ocelli are consistently present laterally on the prodorsum (Lindquist, 1985). In the Tydeidae (including *O. stepheni*) no ocellus-like differentiated surface cuticle is visible, but so-called ocelli in the form of aggregates of pigment granules in the integument are present (Evans, 1992).

Eriophyoidea mites are characterized as being without eyes (Lindquist, 1996a). There are, however, sometimes one or two ocellus-like structures present on each posterolateral area of the prodorsal shield that may be light-receptive organs (Keifer, 1975a; Lindquist, 1996a). For the present study it is presumed the ocellus-like structures in the Eriophyoidea and the ocelli in the Tetranychidae are homologous. In the Eriophyoidea classification (Amrine *et al*., 2003) a systematic pattern in the species with these ocellus-like structures is not apparent and they occur in several species of different genera in the Phytoptidae and the Eriophyidae (Flechtmann *et al.*, 1995; Lindquist, 1996a). Among the Eriophyoidea species included in the present study, three species have ocellus-like structures: *Ectomerus anysis* (Eriophyidae: Cecidophyinae) (Keifer, 1970), *Novophytoptus stipae* (Phytoptidae: Novophytoptinae) (Keifer, 1962d) and *Palmiphytoptus oculatus* (Phytoptidae: Sierraphytoptinae) (Navia & Flechtmann, 2002). It will be an improvement to divide this character in future studies into two or more characters: ocelli or ocellar-like areas present or absent, and a second character to score the shape of these, and another character to score the number of ocelli present. For the latter two characters for those species with these structures absent, the score will be "not applicable".

Characters 62-66. The prodorsal shield may have an anteromedian extension "frontal lobe", "anterior lobe" or "prodorsal shield lobe" (the term "frontal lobe" was preferred by Amrine (1996) and is used in the present study). The presence or absence of the frontal lobe, together with other frontal lobe and opisthosomal characteristics, is significant at the subfamily, tribe and genus level of the present Eriophyoidea classification (Lindquist & Amrine, 1996; Amrine *et al.*, 2003). A well-developed frontal lobe may provide rigid support for the gnathosoma of free-living eriophyoids which feed on more exposed and thick-walled cells than species living in protected areas like galls (Shevchenko, 1970). Some characteristics of the frontal lobe, e.g., the presence of spines or other processes, defining genera, are regarded as being trivial by some authors (Lindquist & Amrine, 1996). The definition and scoring of all characters regarding the frontal lobe should be improved in future studies.

**62. Frontal lobe (Figs 3.2, 3.4) – presence and shape:**

0 = absent
1 = short or indistinct (not reaching across cheliceral bases)
2 = present
3 = absent, shield with deep invagination

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 109, Character 5: 0 = absent; 1 = present). They scored the frontal lobe as being absent in the Tydeidae.

Interpretation, delimitation of character states, scoring and subsequent coding is highly subjective and ambiguous for this character. In practical taxonomy (description, classification and identification) of Eriophyoidea the frontal shield lobe is considered present when it is extending across the motivator or bases of the chelicerae (Amrine *et al*., 2003; Amrine, *pers. comm.*). For determining homologies this is an artificial delimitation, because some *Aceria* and *Diptilomiopus* spp., and species of many other genera described and even depicted without a frontal lobe, clearly possesses a structure that is homologous with other conventionally recognized frontal lobes, particularly when studied with SEM (see Chapter 3).

The frontal lobes of species scored as character state “short or indistinct” actually groups two types of frontal lobes which are not homologous: a thin, apparently flexible lobe e.g., in *Diptilomiopus*, *Aceria* and *Eriophyes* spp. and a short but more thick and rigid lobe, e.g., in *Cecidophyes* spp. They have the characteristic in common that their frontal lobes are not extending across the cheliceral bases and motivator. Additionally the differentiation of this state from the state where the frontal lobe is present is subjective. This character must be carefully redefined, using e.g. SEM studies to determine true primary homologies between the frontal lobe characteristics.

The character states scored for the following species, in particular, are ambiguous:

- *Davisella breitlowi*: in the text, the frontal lobe is described as being absent (“dorsal shield not projecting over rostral base”), and a frontal lobe does not seem to be present in the drawing of the lateral aspect, however, in the dorsal view drawing (Davis, 1964a), it seems that the prodorsal shield may overhang the gnathosoma anteriorly. The frontal lobe is scored “absent” for this species in the present study.

- Although *Hyborhinus kallarensis* is described as having a short projection of the shield over the gnathosomal base (Mohanasundaram, 1986) similar to *Catarhinus*, in the dorsal view drawing the anterior edge of the shield and its possible frontal lobe does not resemble that of *Catarhinus*, and seems more similar to *Hoderus roseus*, in which the frontal lobe was described as being absent. The frontal shield is scored as “absent” for this species in the present study.
- The recorded presence of the frontal lobe in *Rhinophytoptus concinnus* and *Rhyncaphytoptus ficifoliae* (Liro, 1943; Keifer, 1939a, respectively) is ambiguous and particularly based on subjective interpretation. Laterally it seems that no appreciable lobe is present, however, dorsally, and in line with the robustness of the body, it seems that the prodorsal shield is extending across the cheliceral bases. It was scored as being “present” for these two species in the present study.

### 63. Frontal lobe – flexibility:

1 = thin and flexible
2 = rigid
3 = absent, shield with deep invagination

This character of the frontal lobe is taxonomically important, but as defined here it overlaps somewhat with the previous character. The character definition should be improved. The frontal lobe is usually more thin and flexible in non-vagrant species, and it is this type of frontal lobe that is frequently recorded as absent, when it is present. For example, when a frontal lobe was recorded or depicted as being present in a *Diptilomiopus* sp. it is presumed to be thin and flexible, similar to the three new species from South Africa, where the lobes are barely visible studying slide-mounted specimens, but clearly present in SEM images (Appendix M). There is a possibility that all *Diptilomiopus* spp. may have a frontal lobe similar to the three new species, but that it was not detected by the authors. A more rigid and extensive frontal lobe is usually present in vagrant species, e.g., in the Phyllocoptinae. The scoring is highly ambiguous for this character.

### 64. Frontal lobe – shape of apical edge:

1 = blunt and rounded
2 = blunt and rounded, but narrow in shape (e.g., when lobe is more triangular)
3 = blunt and rounded with irregular edge
4 = sharply pointed
5 = spine-like

6 = square with rounded corners
7 = rectangular anterior lobe with indentation
8 = acuminate, but not sharply pointed
9 = small indentation
a = broad, clear indentation with broad lobes
b = fine, slender lateral extensions
c = short, bilobed with small central triangle

Similar to previous characters of the frontal lobe, this character is also subjectively and ambiguously described and scored. In the present study the state was usually determined on the descriptive drawings. It is used in the Eriophyoidea classification usually at genus level, for example, the frontal lobe is sharply pointed in *Aculops* spp., and more rounded in *Aculus* spp. (both of the Phyllocoptinae), and this is essentially the only characteristic differentiating these two genera (Amrine *et al*., 2003). The character has potential to be phylogenetically informative, but its definition should be improved, primarily by studying frontal lobes more carefully, and in their true and natural state as far as possible.

### 65. Frontal lobe or shield – presence and number of spines on anterior edge:

0 = absent
1 = one spine present
2 = two spines present
3 = three spines present
4 = four spines present
5 = with several tooth-like projections on apex

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 109, Character 6: 0 = absent; 1 = present).

It is uncertain whether each spine present in one species is homologous with a spine present in another species at the level of preciseness of morphological study generally undertaken for taxonomy. A more reliable determination of primary homology might be possible incorporating careful comparative morphological, anatomical and ontological study. This character is thus ambiguous, but it is used as such in Eriophyoidea taxonomy.

### **66. Frontal lobe – presence of one slender projecting filament:

0 = absent
1 = present

The anterior edge of the frontal lobe of *Acarhynchus filamentus* (Diptilomiopinae) has a filament curving down in front of the gnathosoma (Keifer, 1959b), and this character state is autapomorphic for this species in the present analyses. It is used in the key to Eriophyoidea genera (Amrine *et al.*, 2003) to key to this genus and species.

### Prodorsal shield ornamentation

The prodorsum is the dorsal surface of the anterior region or prosoma of mite bodies. The prodorsum in the Eriophyoidea is easily distinguishable from the opisthosoma (Figs 3.2, 3.3) because it lacks the transverse annuli or other transverse partitions of the opisthosoma and is always covered by a shield, named the "shield", "dorsal shield", "cephalothoracic shield", "propodosomal shield" and "anterior shield" in the Eriophyoidea literature (Lindquist, 1996a).

**67. Prodorsal shield ornamentation – presence:**

0 = prodorsal shield similar to that of the Eriophyoidea absent
1 = ornamentation absent (prodorsal shield essentially smooth)
2 = absent centrally, ornamented along edges
3 = faint, obscure or virtually unornamented
4 = ornamentation present

A prodorsal shield similar to that in the Eriophyoidea is not present in *O. stepheni* (Fig. 4.1) and *M. yemensis* (Fig. 4.2). Their prodorsums are covered with striae similar to striae on the remainder of the body.

The prodorsal shield in the Eriophyoidea may be smooth or nearly smooth, or it may be ornamented (Figs 3.3a–c) with various markings and ridges forming an essentially species distinctive pattern, although it may have more or less intraspecific variation, depending on the species. It may lend itself to be regarded as the "finger print" of a species (J.W. Amrine Jr., *pers. comm.*). These markings may in part reflect the pattern or position of muscle insertions (Lindquist, 1996a), and may also provide a framework of strength to the shield (Shevchenko, 1970). The scoring of this character was subjective, particularly when the prodorsal shield is smooth or nearly smooth, in comparison with faintly or sparsely ornamented.

## IDIOSOMA

***68. Opisthosomal lyrifissures (cupules or slit organs) – presence:**

0 = present
1 = absent

Opisthosomal lyrifissures are widely distributed in the Arachnida, and are mechanoreceptors measuring strains or loads induced by muscular activity, substrate vibrations and haemolymph pressure (Evans, 1992). The distribution of cuticular organules like lyrifissures and setae are often used as indicators of segmentation (Evans, 1992). Lyrifissures are present in the Tydeidae, including *O. stepheni*, and in the Tetranychidae, including *M. yemensis*, but are absent in the Eriophyoidea.

### *69. Opisthosoma of female caudal rear end – shape:

0 = rounded and without adhesive anal structure
1 = acuminate with adhesive anal structures

The opisthosoma of the Eriophyoidea is more or less acuminate caudally and the rear ends in two adhesive lobe-like structures (Fig. 3.2).

## Opisthosomal shape and microtuberculation

### 70. Body shape:

0 = varying from rounded to oval (e.g., Tetranychidae)
1 = vermiform (worm-like) (e.g., *Phytoptus* and *Aceria* spp.)
2 = cylindrical (e.g., *Austracus havrylenkonis* and *Novophytoptus rostratae*)
3 = vermiform, elongated (e.g., *Cecidodectes euzonus* and *Pentasetacus araucaria*)
4 = vermiform, extremely elongated (e.g., *Novophytoptus stipae* and *Scoletoptus duvernoiae*)
5 = fusiform, medium thick to “fat”, with or without narrower rear end (e.g., *Africus psydraxae*, *Arectus bidwillius* and most *Diptilomiopus* spp.)
6 = fusiform, elongated, medium thick (e.g., *Aculus* and *Abacarus* spp.)
7 = fusiform, flattened (e.g., *Anthocoptes gutierreziae* and *Calepitrimerus cariniferus*)
8 = fusiform, extremely flattened (e.g., *Setoptus jonesi* and *Tergilatus sparsus*)
9 = fusiform, very long (e.g., *Notostrix attenuata* and *Ashieldophyes pennadamensis*)
a = fusiform, broad anteriorly, very narrow tail (e.g., *Nothacus tuberculatus*)
b = fusiform, flattened, narrow tail (e.g., *Aberoptus samoae*)

This character was previously used in analyzing the phylogeny of the Eriophyoidea [Hong & Zhang, 1996a, p. 110, Character 9: 0 = worm-like; 1 = fusiform (spindle-shaped)]. They scored the character in the Tydeidae as being worm-like, which is incorrect.

Similar to most mite species, the body shape of the Tenuipalpidae (including *O. stepheni*) and the Tetranychidae (including *M. yemensis*) is about rounded to oval (Figs 4.1, 4.2). Eriophyoidea mites by and large have a worm-like shape due to their elongated opisthosoma (Fig. 3.2). The more specific body shape of species, genera or higher groupings is generally described as vermiform (worm-like) (Fig. 3.2a) or fusiform (spindle-shaped) (Fig. 3.2b). Vermiform species have a more elongated, flexible body and is more characteristic of non-vagrant species living in sheltered spaces (e.g., in buds, galls, erinea and under leaf sheaths). Fusiform species have a less elongated body, can be arched dorsally, and often with fewer, thicker and less flexible annuli and other structures dorsally, and is more associated with vagrant species occupying exposed habitats. In some aspects body shape is thus probably heavily influenced by the habitat a species occupies.

When the body shapes are more closely scrutinized and compared, however, many more subgroups of shapes can be distinguished than the two main shapes mentioned above. In the present study body shape has been divided in ten states for the Eriophyoidea, but this is a very preliminary definition of the character, and it should be studied more closely to properly define and demarcate states. For example, states vermiform, elongated vermiform and extremely elongated vermiform may be homologous in shape to each other and rather differentiated in body length (another character), however, there is a difference in shape due to difference in length, thus they were coded separately.

Although quite accurate in the extreme shapes, determining body shape is subjective. The problem of objectivity and standardization is further exacerbated by distortion of body shape in slide-mounted specimens. When determining states from published descriptions, schematic or semi-schematic drawings may not truly portray body shape, and interpretation of shape by the descriptor is also subjective. e.g., *Phyllocoptruta oleivora*: in the descriptive drawing by Keifer (1938a) one may describe the shape from dorsal and lateral views as “fusiform fat”, and later in additional drawings of the lateral view of this species (Keifer, 1952b) the shape could be scored as “fusiform flat”.

Body shape, together with other body characteristics, however, is presently an important character in the higher classification of the Eriophyoidea and it is included in the present study, despite the subjectivity and ambiguity, also to evaluate the phylogenetic signal in the character.

The character states scored for the following species, in particular, are ambiguous:

- *Bakeriella ocimis*: body shape is somewhat similar to that of *Diptilomiopus* spp. (“fusiform, medium thick to fat”) with a more rounded body in transverse section with a broad anterior part narrowing quite steeply to the rear in lateral view (Chakrabarti & Mondal, 1982), however, the dorsal aspect is fairly rigid and flatter than in e.g., *Diptilomiopus* spp. and character state “fusiform, flattened”, has been assigned to this species. The ventral aspect of the body depicted, could be expanded more, away from the dorsum, than natural, due to slide-mounting. A new state could possibly be considered in future for this shape.

- *Pentaporca taiwanensis*: body shape is described as spindle-form (Huang & Boczek, 1996), but it is impossible to determine the exact fusiform shape from the descriptive drawings. For the present study it has been decided to score it as “fusiform, medium thick to fat”, because in the parts depicted, the mite seems to be more rounded.
- *Pararhynacus photinae*: this species was scored the state “fusiform, broad anteriorly, very narrow tail”, but it could possibly be the style of the drawing by Kuang (1986a), and the shape may be “fusiform fat”, similar to many species in the Diptilomiopinae, including most of the *Diptilomiopus* spp.
- *Euterpia fissa*: body shape is described as “fusiform” (Navia & Flechtmann, 2005), but based on the body composition (as depicted in the drawing of the ventral aspect) being similar to that of *Tergilatus sparsus*, particularly in the extension of the lateral areas alongside the ventral annuli, this species may be extremely flattened, and the state “fusiform, extremely flattened” was assigned to it.
- *Neolambella ligustri*: body shape in lateral view was not depicted by Lin & Kuang (1997), but it is presumed to be more “fat” than flattened, because this group of mites in possibly closely related genera all seem to have in general about the same body shape than most *Diptilomiopus* spp.
- *Fragariocoptes setiger*: body shape was depicted in the original description by Nalepa (1894) as being elongated fusiform, but in the redescription by Boczek (1964) and Roivainen (1951), it was depicted as closer to short fusiform and slightly flattened dorsoventrally. To allow for both shapes until the exact shape and variation therein has been sorted out, the states “fusiform, elongated, medium thick” and “fusiform, flattened” were assigned to it.
- *Diptilomiopus camarae*: body shape was described as “worm-like” (Mohanasundaram, 1981b), however, based on the descriptive drawings, the shape rather seems to be fusiform, but additionally elongated, and the state “fusiform, elongated, medium thick” was assigned to it.

### *71. Opisthosoma – presence of annuli:

0 = without annuli
1 = with annuli

The body surface of the Tenuipalpidae (including *O. stepheni*) and the Tetranychidae (including *M. yemensis*) is striated (Figs 4.1, 4.2), but does not have annuli homologous with the series of transverse superficial rings or annuli present in all active instars of Eriophyoidea mites. These annuli in the Eriophyoidea encircle the body entirely (Fig. 3.2). In the present study this is an autapomorphic character state for the Eriophyoidea, but similar annuli are found in two other mite groups living in minute spaces, namely the Demodicidae (living in hair follicles and similar habitats on mammalian hosts) and the Nematalycoidea (living in tightly confined spaces in the soil) (Krantz, 1978). Lindquist (1996b) attributed the presence of similar annuli, as well as some other characteristics that are similar between these three groups as convergent or parallel development of characters in response to miniaturization and living in extremely small, confined spaces.

### 72. Opisthosoma dorsoventral differentiation; annuli presence, number and appearance (Fig. 3.2):

0 = annuli absent
1 = subequal and similar in appearance, dorsally and ventrally (Fig. 3.2a)
2 = subequal, differentiated in appearance dorsally and ventrally
3 = subequal, numerous, and visibly narrower than usually found in the Eriophyoidea
4 = subequal or equal in count, but broader than usually found in the Eriophyoidea
5 = differentiated into slightly broader dorsal annuli and narrower ventral annuli
6 = clearly differentiated into broader dorsal annuli and narrower ventral annuli (Fig. 3.2b)
7 = dorsal annuli extremely broader than ventral annuli
8 = variably different (e.g., *Paraphytoptus*)

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 114, Character 28: 0 = absent; 1 = differentiates into broader dorsal annuli [tergites] and narrower ventral annuli [sternites]).

The body surface of the Tenuipalpidae (including *O. stepheni*) and the Tetranychidae (including *M. yemensis*) does not have annuli homologous with the annuli present in all active instars of all Eriophyoidea mites (see Character 71), and were scored “annuli absent”. Annuli in the immature stages (larva and nymph) of the Eriophyoidea are usually numerous, similar in form from anterior to posterior body regions, and is very little, if at all, differentiated in shape and number dorsally and ventrally (Lindquist, 1996a). In adults the annuli shapes can be divided in about two major forms that are mostly strongly correlated with the habitat and living conditions of the mites (Lindquist, 1996a). The species living in more sheltered and enclosed spaces e.g., in galls, usually retain a more vermiform body, with relatively numerous annuli differentiated very little or not at all from the anterior to the posterior end of the body, and annuli are subequal in number and not differentiated in shape dorsally and ventrally (Fig. 3.2a). The group of species living exposed on e.g., leaf surfaces, or more fusiform mites, usually has a relatively shorter body, with annuli differentiated dorsoventrally to varying degrees with broader, fewer, more robust, thicker and less flexible dorsal annuli (previously named tergites), with the ventral annuli (previously named sternites) remaining narrower and more flexible (Fig. 3.2b). A conspicuous example of these two different forms can be seen in *Paraphytoptus* spp. which lives with the front end sheltered in erineum, and the rear end usually exposed outside the erineum. In this genus the front end is similar to a vermiform mite, and the rear end similar to the exposed or fusiform mites (Keifer, 1975a).

On closer inspection the differentiation of annuli can be divided in more states than merely the two major groups. In the present study the character has seven states for the Eriophyoidea, but this is only a preliminary division, and the states should be scrutinized and their definition and demarcation should be improved. Especially the state "variably different" is not defining a specific morphological change in morphology, but rather is a category where all shapes that can not be defined by the other states, are "dumped".

The character states scored for the following species, in particular, are ambiguous:

- *Neolambella ligustri*: the dorsoventral differentiation of the annuli was not described, neither specifically depicted in the description of this species by Lin & Kuang (1997), but based on the group of mites to which this species is similar (*Diptilomiopus*-like species in the Diptilomiopinae) and the relative width of the annuli in the partial dorsal and ventral view drawings, it was scored "differentiated into slightly broader dorsal annuli and narrower ventral annuli".
- *Neodiptilomiopus vishakantai*: dorsal and ventral annuli may be subequal, rather than differentiated. There are only 5 more ventral than dorsal annuli (Mohanasundaram, 1982b). The species was scored "differentiated into slightly broader dorsal annuli and narrower ventral annuli".
- *Pararhynacus photiniae*: the differentiation between the dorsal and ventral annuli could not be determined from the description, Kuang (1986a), however, stated that *Pararhynacus* is similar to *Rhynacus*, and the annuli are slightly differentiated in *Rhynacus* and was scored as such for *Pararhynacus*.
- *Indonotolox sudarsani*: the annuli of *Indonotolox* were described to have the dorsal annuli broader than ventral annuli; however, in the type species of the genus, *Indonotolox sudarsani*, described in the same article, the annuli were described as being equal in number dorsally and ventrally. In the lateral view drawing the annuli seem broader than generally found in the Eriophyoidea with subequal annuli dorsoventrally, and in the ventral view drawing the annuli

seem to be narrower (Ghosh & Chakrabarti, 1982). The annuli for this species were scored as "subequal or equal in count, but broader than usually found in the Eriophyoidea".

**73. Lateral extensions on opisthosomal dorsal annuli – presence and shape:**

0 = without lateral extensions or lobes
1 = very slight lateral projection (no demarcation line laterally)
2 = with slight lateral projection (in lateral view, dorsal annuli separated from ventral annuli by some sort of demarcation); the extend of lateral projection not always clear, some of these species are not in Tegonotini
3 = with clear lateral extensions or lobes (currently defining state for Tegonotini)
4 = small spine-like lobes on margin between dorsal and ventral annuli
5 = extensive lateral lobes, also present dorsally
6 = ventro-lateral ridges forming grooves
7 = lateral lobes uneven, extending more from some annuli

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 114, Character 29: 0 = not extended laterally; 1 = extended laterally or with indentations).

Particularly in species living exposed and with the body more fusiform and dorsal annuli broader and more rigid than ventral annuli, the dorsal annuli may be differentiated into various structures. Some of these modifications are the extension of some or all dorsal annuli laterally into lobes of various shapes, thickenings and the consolidation of some dorsal annuli into plates (Lindquist and Amrine, 1996), and these types of modifications presently largely define the tribe Tegonotini (Eriophyidae: Phyllocoptinae) (Lindquist and Amrine, 1996). I found the distinction between the presences or absences of lateral lobes unclear and subjective, e.g., compare *Acarelliptus cocciformis* (Phyllocoptini) (Keifer, 1940b) with *Tegonotus mangiferae* (Tegonotini) (Keifer, 1946). The lateral lobes of some *Tegonotus* and *Shevtchenkella* spp. are even less pronounced than in the latter two species. The scoring of this character is subjective, and influenced by the interpretation of various descriptors, and additionally the character should be redefined.

The character state scored for the following species, in particular, is ambiguous:

- *Neopropilus jatrophus*: presence of lateral lobes in the species was not mentioned in the description by Huang (1992), and the presence thereof in the SEM images provided with the description, and descriptive drawings by Amrine *et al.* (2003) are not conclusive, however, the dorsal annuli seem to extend somewhat laterally, and the state "with slight projection" was scored for this species in the present study.

**74. Opisthosoma: ridge(s) and/or furrow(s) – presence and some shapes:**

0 = absent
1 = present
2 = absent, except for some rear dorsal annuli which are higher than the others
3 = some anterior dorsal annuli fused into elaborate dorsal structures
4 = with large lobes dorsally
5 = dorsal annuli undulate, forming about regular rows of lobes, or "ridges"
6 = deep cleft behind prodorsal shield, first two dorsal anterior annuli raised

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 113, Character 23: 0 = absent; 1 = present).

The dorsal annuli of the Eriophyoidea may have various forms of ridges, lobes and troughs, and similar to Character 73 (lateral extensions or lobes) it largely occurs in species living exposed and with the body more fusiform and with dorsal annuli broader and more rigid than ventral annuli. The presence and shape of dorsal ridges and troughs or furrows are used very predominantly in the classification of the Eriophyoidea to define particularly genera. Evaluation and very detailed, precise demarcation of these modifications in separate discrete states and homologous structures may not be so important in classical classification and identification, but is crucial for studying phylogenetic relationships. Particularly in this character as defined here, a large amount of variation is grouped and masked within a relatively few states of one character. The detailed variation of these body modifications is thus largely ignored in the present study. It was decided not to score the different types of ridges and furrows and other body modifications in detail, because the definition of homologies and states is complex, subjective and ambiguous, and I didn't want to complicate the data set with ambiguous data any more than it already is.

Ridges and troughs are very susceptible to distortion in slide-mounted species, however, and particularly when the ridges or troughs are less pronounced (weak), they may be overlooked or interpreted wrongly. For example in some *Diptilomiopus* spp. (like *Diptilomiopus aralioidus*, *D. alagarmalaiensis*, and *D. malloti*) (Huang, 2006; Mohanasundaram, 1986; Wei & Feng, 1999, respectively) the presence of ridges or troughs are neither described nor depicted, however, for the present study it is presumed ridges are present in *Diptilomiopus*, since they are so weak and subtle, that they could easily have been overlooked. However, in a parallel study in progress (C. Craemer, *unpubl. data*) including phylogenetic analyses of *Diptilomiopus* spp., the ridges and furrows are described and coded in more detail, and some of the problems with interpretation, and state definition and scoring are discussed there.

The character states scored for the following species, in particular, are ambiguous:

- *Asetadiptacus emiliae*: ridges and furrows were scored as "absent", and this decision is substantiated by the couplet decision which key out to this species, "dorsal opisthosoma evenly rounded" (Amrine *et al*., 2003). The species was specifically described as having the opisthosoma without any ridges or furrows; and this state was used by Carmona (1970) to differentiate *Asetadiptacus* from *Diptacus*. In the descriptive drawings (Carmona, 1970), however, it seems that a slight middorsal ridge, subdorsal furrows and sublateral ridges may be present, similar to those in most *Diptilomiopus* spp.
- *Duabangus chiangmai*: only two weak lateral ridges are present low down on the body in the descriptive drawing by Chandrapatya & Boczek (2000b), but the dorsum is rather evenly rounded. The species was scored to have ridges, but it is ambiguous.
- The body shape, regarding presence of ridges and/or troughs, is not described for *Diptilomiopus maduraiensis* and *D. thangaveli* and in the descriptive drawing the body seems to be evenly rounded without any ridges or troughs (Mohanasundaram, 1986a; 1983c, respectively). However, the species may have a slight middorsal ridge possibly flanked by troughs forming lateral ridges, similar to most other *Diptilomiopus* spp.; these may have been obscured by the mounting process. Ridges and troughs in these two species were scored to be absent. Similarly, the body shape regarding presence of ridges and/or troughs was not described in the text description of *Diptilomiopus ulmivagrans* but in the drawing the body seems to have a slight middorsal ridge (Mohanasundaram, 1984); this is similar to what is found in most other *Diptilomiopus* spp. The latter species was scored as if it has a ridge.

In their phylogenetic analysis of the Diptilomiopinae Hong & Zhang (1997) coded ridges or furrows (troughs) on the opisthosoma present for the genus *Diptilomiopus*. It may not be that all species currently assigned to *Diptilomiopus* have ridges and/or furrows. Furthermore, the shape and presence of ridges and furrows of *Diptilomiopus* spp. vary, and if sufficiently studied and described in more detail, differences may define different groupings within the genus that may even be similar to genus level groupings in other Eriophyoidea taxa. These differences are usually very subtle, though, and one might only be able to score the character states from SEM images.

### 75. Fusion of rear dorsal annuli – presence:

0 = without annuli
1 = not fused
2 = fused

The annuli and microtubercles in the rear portion of the opisthosoma, from the opisthosomal *f* to the anal lobes, in most species are different from the remainder of the opisthosoma, but in some species they are the same. The microtubercles ventrally on the annuli in this area are distinct, elongated and rib-like in most species (Keifer, 1966d). Keifer (1966d) named this part of the opisthosoma the telosome for descriptive purposes, but the use of the term is discouraged (Amrine *et al*., 2003). Although the telosome is an artificial region (Lindquist, 1996a), the term is useful in descriptions. For the present study it is presumed there is not a region homologous with the telosome in the Tenuipalpidae (including *O. stepheni*) and the Tetranychidae (including *M. yemensis*).

The dorsal annuli beyond *f* up to the anal lobes are characteristically fused in a few species in the Phytoptidae, and four of these are included in the present study: *Neopropilus jatrophus*, *Propilus gentyi* and *Retracrus johnstoni* in the Sierraphytoptinae and *Prothrix aboula* in the Prothricinae (Huang, 1992; Keifer, 1975d; 1965c; 1965a, alternatively). When this opisthosomal region is not described neither depicted for a species, it is presumed the annuli are not fused, because they are not usually fused within the Eriophyoidea. If they were fused, it is presumed the author(s) would have recorded it, because it is a conspicuous character state.

### <u>76. Microtubercles on dorsal annuli – presence:</u>

0 = without microtubercles (mostly smooth)
1 = entirely microtuberculated
2 = entire but mostly obscure or faint
3 = smooth with few scattered microtubercles in sparse clumps (laterally and/or middorsally) (see *Chiangmaia longifolii*) or with clumps or spots with microtubercles (see *Duabangus chiangmai*)
4 = smooth with microtubercles on ridges: lateral (see *D. stephanus*); relatively large spines on ridges (see *Pentamerus rhamnicroceae*)
5 = faint but clear on lateral ridges (see *Notallus nerii*)
6 = with central area smooth, and microtuberculated laterally
7 = mostly smooth with few microtubercles laterally and caudally (see *D. knorri*)
8 = with faint or no microtubercles anteriorly, clearly microtuberculated towards rear (see *D. davisi*)
9 = microtuberculated anteriorly, rear annuli smooth (see *Indosetacus rhinacanthi*, *Arectus bidwillius*) or smooth with microtubercles mediodorsally on anterior annuli
a = smooth with microtubercles on the first few anterior and posterior annuli (see *Scoletoptus duvernoiae*)
b = elongated or near elongated microtubercles aligned in longitudinal rows
c = punctuate becoming smoother towards rear (see *Porosus monosporae*)
d = punctuate dorsally, elongated ridges laterally, intercepted by smooth annuli (see *Cymeda zealandica*)
e = crossed by fine broken lines (see *Peralox insolita*)
f = elongated fissures (see *Rhinotergum schestovici*)

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 115, Character 34: 0 = absent; 1 = present). Hong & Zhang (1996a) simply coded the dorsal annuli as smooth or with microtubercles present. The presence or absence of microtubercles are more complex, though, ranging from dorsal annuli entirely without microtubercles ("smooth") to the dorsal annuli entirely with microtubercles.

Microtubercles are rounded, ridge-, spine-like or other shaped protuberances usually in single rows on or along the annuli margins when present in Eriophyoidea species. They usually occur on the ventral annuli about uniformly, but may be sparser, of a different shape or absent on the dorsal annuli. The presence and other characteristics, including shape and position, of the microtubercles are usually used at species level. Similar to many other characteristics of the body, the presence and density of microtubercles on mainly the dorsal annuli correspond with the lifestyle of the species. More vermiform, non-vagrant species, generally have numerous and well-developed microtubercles, also dorsally, and more fusiform vagrant species, tends to have less or no microtubercles, especially dorsally. Microtubercles are probably correlated with water loss and mobility (Lindquist, 1996a).

The homology between the microtubercles found in the Eriophyoidea and the lobes occurring on the striae of the Tenuipalpidae (including *O. stepheni*) and the Tetranychidae (including *M. yemensis*) could not be researched in depth for the present study, but superficially it seemed that they may possibly be homologous, and character states were assigned as such. Thus microtubercles were designated as being present on the entire dorsal surface of *O. stepheni* and *M. yemensis*.

Similar to most of the more complex characters of the Eriophyoidea, the definition of this character, particularly for use in phylogenetic analyses, needs to be improved. It was initially defined with more than 16 states, but 16 were eventually chosen to be the maximum number of states, and some states had to be combined with others. The states are thus not optimally differentiated. The definition of these characteristics might be improved by first dividing the dorsum into homologous regions, and treating each region as a separate character with defined character states.

The character states scored for the following species, in particular, are ambiguous:

- *Proneotegonotus antiquorae*: the character was initially scored as "smooth, faint longitudinal lines on first enlarged dorsal annulus", but for the analyses the number of states for this character had to be reduced, and the state for this species was changed to "without microtubercles; mostly smooth". Although longitudinal lines occur on the first enlarged dorsal annulus (Mohanasundaram, 1983a), these longitudinal lines are probably not microtubercles.

- *Diptilomiopus azadirachtae*, *D. guajavae*, *D. riciniae* and *D. swieteniae*: dorsal annuli were described as smooth, respectively by Boczek & Chandrapatya (1992b), Mohanasundaram (1985), Boczek & Chandrapatya (2002), and Chandrapatya & Boczek (1998). In all or at least one of the descriptive drawings of each of these species, however, microtubercles are clearly depicted on the dorsal annuli, and species were scored to have microtuberculated dorsal annuli.
- *D. coreiae* and *D. melastomae*: dorsal annuli were described as being smooth (Chandrapatya & Boczek, 2002b; Boczek & Chandrapatya, 2002, respectively), but a few scattered microtubercles were clearly depicted laterally on the dorsal annuli, and the species were scored as "smooth with few scattered microtubercles in sparse clumps (laterally and/or middorsally)".
- The dorsal annuli were recorded in the descriptive text as smooth (Mohanasundaram, 1981b) in *D. camarae*, however, fine tubercles are depicted dorsally on caudal annuli, and plausibly also for the lower lateral parts of the dorsal annuli, and it was scored "mostly smooth with few microtubercles laterally and caudally" similarly to *D. knorri*.
- The character was not described for *Diptilomiopus aralioidus*, *D. commuiae*, *D. cumingis*, *D. elliptus*, *D. maduraiensis*, *D. perfectus*, and *D. championi* (description of *D. septimus*) (Huang, 2006; 2001b; 2001a; 2001d; Mohanasundaram, 1986; Huang, 2001c, respectively), but the dorsal annuli were depicted without microtubercles in the accompanying descriptive drawings, and the microtubercles were scored as absent. Drawings are not always accurate regarding the presence of microtubercles, since some detail, including microtubercles, are not always included in semi-schematic drawings, particularly when presented at a small scaled size.
- The dorsal annuli were described as smooth for *D. securinegus*; however, in the descriptive drawings and accompanying SEM images (Boczek & Chandrapatya, 1992a), microtubercles are clearly present on the lateral areas of the dorsal annuli, and the species was scored "with central area smooth, and microtuberculated laterally".
- *Lithocarus thomsoni*: dorsal annuli were described as smooth (Chandrapatya & Boczek, 2000c), however, in the accompanying descriptive drawing some microtubercles were depicted on some of the dorsal ridge lobes. The species was scored "smooth with microtubercles on ridges".
- Dorsal annuli of *Chiangmaia longifolii* were described in the text as smooth; however, in the descriptive drawings a few scattered microtubercles are present (Chandrapatya & Boczek, 2000c). The species was scored for the present study as "smooth with few scattered microtubercles in sparse clumps (laterally and/or middorsally)".

## Secretions

### 77. Wax secretion – presence:

0 = absent
1 = present in adults
2 = present only in immatures

Wax, secreted by them, occurs on the bodies of some Eriophyoidea species. The wax probably adds protection against desiccation and may possibly be a deterrent against predators. The presence of other secretions e.g., a liquid globule covering the body of *Hoderus globulus* (Mohanasundaram, 1981) (Mohanasundaram, 1981e) and *Rhyncaphytoptus constrictus* (Hodgkiss, 1913) (Hodgkiss, 1930; Baker *et al*., 1996) probably with the same function as wax, was not included in the present study, but should be included in future studies. Twenty-seven of the Eriophyoidea species in the present study secrete wax, and it occurs on the adults, except in one species, *Rhyncaphytoptus ficifoliae*, where the wax is only present on the immatures (Keifer, 1939a). The wax secreting species occur in all three families, but especially in species that have a more exposed, vagrant lifestyle. The species with wax are listed in Table B.3, including the structures from which the wax is probably secreted. Extrapolated from the Eriophyoidea classification it seems that the ability to secrete wax possibly developed homoplasiously (parallel evolution) in at least three lineages.

**Table B.3.** List of Eriophyoidea species with wax, including their classification and structures from which the wax is probably secreted, or on which it occurs. The data were obtained from the original descriptions of the mites.

| **Classification** | | **Species** | **Structures etc.** |
|---|---|---|---|
| **Phytoptidae** | | | |
| Sierraphytoptinae | Mackiellini | *Retracrus johnstoni* | tubercles |
| **Eriophyidae** | | | |
| Phyllocoptinae | Acaricalini | *Cymeda zealandica* | rim |
| | | *Notacaphylla chinensiae* | tubercles |
| | | *Paracaphylla streblae* | covered |
| | Anthocoptini | *Abacarus acalyptus* | ridges |
| | | *Abacarus hystrix* | ridges |
| | | *Aculodes mckenziei* | powdery |
| | | *Costarectus zeyheri* | tubercles |
| | | *Keiferana neolitseae* | covered |
| | | *Neomesalox kallarensis* | ridges |
| | | *Pentamerus rhamnicroceae* | tubercles |
| | | *Porcupinotus humpae* | ridges |
| | Calacarini | *Calacarus pulviferus* | tubercles |
| | Phyllocoptini | *Acamina nolinae* | ridges |
| | | | |
| **Diptilomiopidae** | Diptilomiopinae | *Apodiptacus cordiformis* | ridges |
| | | *Dialox stellatus* | tubercles |
| | | *Diptacus sacramentae* | tubercles |
| | | *Diptilomiopus artocarpae* | patches |
| | | *Diptilomiopus melastomae* | covered |

| | | | |
|---|---|---|---|
| | | *Duabangus chiangmai* | tubercles |
| | | *Lambella cerina* | ridges |
| | | *Levonga papaitongensis* | covered |
| | | *Neodialox palmyrae* | ridges |
| | | *Trimeroptes eleyrodiformis* | ridges |
| | Rhyncaphytoptinae | *Asetacus madronae* | covered |
| | | *Konola hibernalis* | powdery |
| | | *Rhyncaphytoptus ficifoliae* | immatures |

In the present study, when no wax secretion or presence of wax were reported or depicted for a species, it is presumed no wax secretions are present. The data for this character are probably riddled with errors, especially in cases where wax may be present, but has been washed off by the slide-mounting process (see Chapter 3).

The character state scored for the following species, in particular, is ambiguous:

- *Suthamus chiangmi* is described as lacking wax (Chandrapatya & Boczek, 2000a), in contrast with the wax secretion found (Manson, 1984a) in the genus *Lambella*, from which it has been differentiated. The ridges of *S. chiangmi* are depicted with thickened edges (Chandrapatya & Boczek, 2000a), and there is a possibility that the ridges may secrete wax similar to *Lambella*.

### 78. Wax type and secreting structures:

1 = present, thickened wax bearing ridges
2 = present, wax from tubercles
3 = broad wax rim around shield, large wax plates along body margin
4 = body covered with wax
5 = sparse wax patches
6 = wax secreting pores on dorsal body surface
7 = covered with white powdery wax

The origin and nature of wax secretions are usually not studied and described in detail to facilitate reliable hypotheses on homologies. Two features of wax secretions can be broadly defined: the origin, or organs or structures secreting wax; and the nature of the wax itself. In order to commence with some sort of analysis, it was decided to take the available information and code it into states including both or either of origin and structure, and separating e.g., a broad definition like "body covered with wax" to more detailed "wax produced from tubercles". This is not a scientifically sound character definition, because two aspects, which may constitute two separate characters, were grouped into one character, but it is hoped that it serves as a starting point for data to be refined and added in future, with improvement of the character definition.

The character state scored for the following species, in particular, is ambiguous:

- Although the detail of wax body coverage or wax secretion was not described for *Duabangus chiangmai* by Chandrapatya & Boczek (2000b), the microtubercles in separate groups suggest that the wax may be secreted from these, and the state "wax from tubercles" was scored for this species, however, "sparse wax patches" may also be applicable.

## LEGS, INCLUDING COXISTERNAL PLATES AND STERNAL AREA

Many characteristics of the legs are autapomorphic for the Eriophyoidea. It is, for example, the only mite group with only two pairs of legs in all the life stages. Some of these characters are here included.

### *79. Larva with:

0 = legs III present
1 = legs III absent

### *80. Larva with:

0 = legs IV present
1 = legs IV absent

### *81. Nymphal instar(s) with:

0 = legs III present
1 = legs III absent

### *82. Nymphal instar(s) with:

0 = legs IV present
1 = legs IV absent

### *83. Adults with:

0 = legs III present
1 = legs III absent

### *84. Adults with:

0 = legs IV present
1 = legs IV absent

### *85. Legs I:

0 = with true (paired) claws
1 = without true (paired) claws

***86. Legs II:**

0 = with true (paired) claws
1 = without true (paired) claws

***87. Legs I:**

0 = with empodia not well-developed “feather-claws”
1 = with empodium a well-developed “feather-claw”

***88. Legs II:**

0 = with empodia not well-developed “feather-claws”
1 = with empodium a well-developed “feather-claw”

***89. Coxisternal plates I:**

0 = clearly separate and not contiguous or fused medially
1 = slightly separate or contiguous or fused medially

***90. Coxisternal plates I:**

0 = not basally contiguous with coxisternal plates II
1 = contiguous basally with coxisternal plates II

***91. Larval instar:**

0 = with urstigmata between coxisternal plates I and II
1 = without urstigmata between coxisternal plates I and II

### Ornamentation on coxisternal plates (Figs 3.4, 3.5)

The coxae in the Prostigmata are immovably fused to the ventral aspect of the body (Kethley, 1990). The coxal remnants are represented by coxal fields (or coxisternal plates *sensu* Lindquist, 1996a, followed in the present study) delineated by internal apodemes from which intrinsic coxal musculature originates. Usually in Eriophyoidea literature, the coxisternal plates are merely referred to as coxae, or coxal plates (Amrine *et al.*, 2003).

The presence and morphology of ornamentation on coxisternal plates I and II are extensively used within the Eriophyoidea to distinguish between species. The ornamentation is frequently described in combination, without distinguishing the differences between coxisternal plates I and II, e.g., merely describing the coxisternal ornamentation as “coxae granulated”. The ornamentation on coxisternal plates I and II is frequently the same type of ornamentation, but often the ornamentation is sparser on the latter, and/or a smaller area of them are covered. This causes problems and errors when the ornamentation of the two pairs of coxisternal plates is homologized and scored as separate characters. Ornamentation on the coxisternal plates is usually described very vaguely and with disregard of true structures and detail. A line depicted on particularly coxisternal plates II can for example be either an internal apodeme, a ridge on the surface, or a folding line caused by slide-mounting. It is usually impossible to distinguish between these types of characters, both from the text description and the descriptive drawing. It is also frequently difficult to distinguish between small, rounded tubercles, and slightly elongated microtubercles, which may rather be defined as dashes. The type of detail found in ornamental structures necessary for accurate determination of homologies, e.g. on the coxisternal plates, are most accurately observable in SEM studies (Chapter 3), in combination with information from slide-mounted specimens.

### 92. Coxisternal plates I ornamentation – presence:

0 = unornamented (mostly smooth) (also scored when described as “virtually unornamented”)
1 = faintly or slightly ornamented
2 = ornamented
3 = body striations extended on legs, including coxisternal plates

The character states scored for the following species, in particular, are ambiguous:

- The coxisternal plates of *Kaella flacourtiae* were described to have some broken lines, however, coxisternal plates I were depicted to be smooth, and the broken lines were only depicted on coxisternal plates II (Chandrapatya & Boczek, 2002b). Usually in the Eriophyoidea, coxisternal plates I are ornamented more strongly or more densely than coxisternal plates II, and it is presumed the drawing might be wrong, and coxisternal plates I and II for this species were scored “ornamented”.
- The coxisternal plates of *Lithocarus thomsoni* were described to be smooth, however, in the descriptive drawing some tubercles were depicted basally on particularly coxisternal plates I (Chandrapatya & Boczek, 2000c). Coxisternal plates I was scored “slightly ornamented”.
- The coxisternal plates of *Steopa bauhiniae* were described to be smooth, however, in the descriptive drawing some slight tubercles and possibly dashes are depicted on particularly coxisternal plates I (Chandrapatya & Boczek, 2001b). Coxisternal plates I was scored “slightly ornamented”, and coxisternal plates II, “smooth”. The description and scoring of *Suthamus chiangmi* (Chandrapatya & Boczek, 2000a) are similar.
- A score of unornamented (smooth) for coxisternal plates I and/or II of the following species is ambiguous: *Acarhis diospyrosis* (coxisternal plates described to be smooth, but single lines were depicted on them in the descriptive drawing) (Chandrapatya & Boczek, 1991c); and coxisternal plates I of *A. siamensis* were described as smooth, however, in the descriptive

drawing, one solid line was depicted about diagonally across the upper right corner of coxisternal plates I and II (Boczek & Chandrapatya, 2000).

### 93. Coxisternal plates II ornamentation – presence:

0 = unornamented (smooth), including virtually unornamented
1 = faintly ornamented
2 = sparsely ornamented
3 = ornamented
4 = body striations extended on legs, including coxisternal plates

The ornamentation on coxisternal plates II is frequently fainter, sparser and less defined than on coxisternal plates I, and it has generally been described less carefully and correctly than for coxisternal plates I. As previously mentioned, there are also frequently folds or underlying apodemes that may be drawn on coxisternal plates II, but which are not necessarily ornamentation on the surface. *Diptilomiopus* spp. were more extensively scored for coxisternal plate ornamentation in a phylogenetic analyses of this genus parallel to the present study, and the plates were subdivided into smaller potentially homologous parts (C. Craemer, *unpubl. data*).

The character states scored for the following species, in particular, are ambiguous:

- *Acarhis diospyrosis*: coxisternal plates were described as smooth, but single lines and dashes are unclearly depicted on the plates in the descriptive drawing (Chandrapatya & Boczek, 1991c). The character was nevertheless scored as "smooth" in the present study.
- *Diptilorhynacus dioscoreae*: the ornamentation of the coxisternal plates was described as "coxae with ornamentation of granules", however, in the descriptive drawing coxisternal plates II are unornamented, and thus without granules (Boczek & Nuzzaci, 1985), and was scored as unornamented in the present study.
- *Lithocarus thomsoni*: the coxisternal plates are described as smooth, however, in the descriptive drawing some tubercles are depicted basally on particularly coxisternal plates I (Chandrapatya & Boczek, 2000c), and the description is thus erroneous, but the ornamentation of coxisternal plates II was nevertheless scored as unornamented.
- Ornamentation on coxisternal plates II was scored as present for the following *Diptilomiopus* and other Diptilomiopinae species, because there were some marks depicted on these plates in the descriptive drawings, but the coxisternal plates may be unornamented in reality:

*D. artabotrysi*
*D. assamica*
*D. boueae*
*D. jasminiae*
*D. racemosae*
*D. elaeocarpi*

*D. jevremovici*
*D. knorri*
*D. strebli*
*D. thunbergiae*
*Acarhis siamensis*
*Africus psydraxae*

**94. Prosternal apodeme between coxae I (Figs 3.4, 3.5) – presence:**

0 = coxisternal plates I more widely separated than in the Eriophyoidea, prosternal apodeme not present, "normal' ventral area extended between coxae
1 = widely separated (see *Davisella breitlowi*, *Neocecidophyes mallotivagrans*, *Palmiphytoptus oculatus* and *Trisetacus ehmanni*)
2 = separated
3 = coxae I touching, usually with sternal apodeme clearly present
4 = sternal apodeme visibly broader than usually found in the Eriophyoidea (see *Rhynacus arctostaphyli*)
5 = totally fused centrally (or prosternal apodeme may be present but effaced – not visible as sternal line in slide-mounted specimens)

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 114, Character 30: 0 = absent; 1 = present).

The prosternal apodeme (called "sternal line" in most Eriophyoidea descriptions) is an internal structure (Lindquist, 1996a). The character state definitions and scoring of this character are subjective and ambiguous. For example, the states "widely separated", "separated" and "sternal apodeme broad" may be confused in different descriptions, and may in reality be broadly the same homologous structure and state, interpreted or observed differently by different authors. For example, the approximation between coxae I of *Acarhis lepisanthis* was described by Keifer (1975d) as a "strong ridge between forecoxae", and it is probably an elevation or ridge on the surface between the coxal plates. Another example is *Asetacus madronae*: Keifer (1952a) described and depicted the approximation between coxae I as "anterior coxae with a sharp ridge between". Whether there is an internal apodeme associated with this ridge is not known, but for the present study the presence of a ridge is regarded as the presence of the prosternal apodeme. These descriptions together with the depiction thereof were interpreted, and the states were scored in the present study as "sternal apodeme visibly broader than usually in the Eriophyoidea". In *Acarhis siamensis*, however, coxae I are described as being "separated, not forming a sternum" (Boczek & Chandrapatya, 2000). One can not deduce from the descriptions and drawings whether the latter and the previous two species have strong, broad sternal apodemes or whether the coxae are separated and without an internal sternal apodeme, and whether the structures are homologous.

*Trisetacus ehmanni* is another example of uncertainty; Keifer (1963b) described "anterior coxae well separated by a low indistinct ridge". In the drawing the coxae seem to be separated and this character of the species was scored in the present study as "widely separated", but the state might rather be "sternal apodeme visibly broader than usually found in the Eriophyoidea". These two states describe two different structures which are not primarily homologous. The "broad sternal apodeme" describe the presence of a certain type of sternal apodeme, while "separated coxae not touching each other" describes the absence of a sternal apodeme, with the inner margins of the coxae separated for an appreciable distance from each other. Sometimes the latter state ("separated") was interpreted in the present study as if the inner coxal margins are touching, even if for a small distance, but the presence of an internal sternal apodeme is not clear or certain e.g., in *Acathrix trymatus* (Keifer, 1962c).

Another example of possible ambiguity: when coxae I are connate medially, but no sternal apodeme is present, or apparently present, e.g., as described for *Leipothrix solidaginis* (Keifer, 1966c), no distinction was made between this state where coxae I may be merely touching without a sternal apodeme, and those species with a sternal apodeme present. These descriptions of this area were scored as "coxae I touching, usually with sternal apodeme clearly present". This mingling of possibly different structures in one state was unavoidable because the presence of an internal apodeme or not, is not well described and distinguished in a bulk of the descriptions, and can not be deduced from the descriptive drawings either. This state should be separated into more states, if the real structures are not homologous.

### **95. Coxae I: sternal region – presence of lobes:

0 = no region homologous to anterior edge of coxisternal plates in the sternal region of the Eriophyoidea
1 = anterior edge of coxisternal plates in sternal region without four lobes
2 = anterior edge of coxisternal plates in sternal region with four lobes

Four finger-like lobes are present on the anterior edge of the coxisternal region (Manson, 1984a) of *Dacundiopus stylosus*, and this character states is autapomorphic for this species. The state is used in the genus key (Amrine *et al.*, 2003) to differentiate *Dacundiopus*.

## LEGS (excluding coxae) (Fig. 3.6)

### **96. Tarsi of legs – presence of shovel-shaped projections:

0 = without shovel-shaped projections on legs
1 = with shovel-shaped projections on legs

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 114, Character 27 (shovel-shaped projections on legs or triangular projections on palp apical ends): 0 = absent; 1 = present).

The shovel-shaped projections occur on the tarsi of *Aberoptus* spp., of which only *A. samoae* was included, and the character state is autapomorphic for this species in the present study. The legs of this genus are generally modified. They are stout, with shortened segments, and the empodia on legs II are large with numerous rays (Keifer, 1951).

### 97. Leg I – femur and genu articulation – whether fused:

0 = normally articulated
1 = division weak, almost fused
2 = not articulated, totally fused
3 = genu present, but "fused" to femur

The character states scored for the following species, in particular, are ambiguous:

- *Diptilorhynacus dioscoreae*: the fusion of the genu with the femur was not recorded in the text description, and furthermore the genu of legs I and II is present in *Diptilorhynacus*, although *l''* is absent on both legs. The genu is fused with the femur in legs I and II in the descriptive drawing (Boczek & Nuzzaci, 1985), however, and was scored as such in the present study.
- The legs of *Lithocarus* were described as six segmented, however, in the descriptive drawing of *Lithocarus thomsoni*, the type species of the genus, the femur and genu were depicted as fused (genu absent) (Chandrapatya & Boczek, 2000c). Amrine *et al*. (2003) corrected the error and the monospecific genus keys out in there key to genera by their five segmented legs, with the genu absent. The genu was scored in the present study as being fused with the femur in both legs I and II.
- Manson (1984a) described the genu and femur to be "almost fused" in *Dacundiopus*, however, in the type species (*D. stylosus*) these segments were described to be "fused" (Manson, 1984a), and in the descriptive drawing it seems that the fusion is complete. The character for this species was scored "totally fused".

### **98. Leg I – division of femur:

0 = undivided
1 = inconspicuously divided
2 = clearly divided

A divided femur is regarded to be plesiomorphic in the Acariformes (Lindquist, 1996a). The femur of *Cymeda zealandica* is clearly divided into two segments (Manson & Gerson, 1986). The femur of *Quintalitus squamosus* was described to be inconspicuously divided (Meyer, 1989c). In the present study, states one and two are autapomorphic for each particular species. In future one could compare the homology of the divisions of the femur, and possibly amalgamate them in one state.

### 99. Leg I – division of tarsus – presence:

0 = undivided
1 = divided

Only three species of the Diptilomiopinae were described with tarsus I divided: *Dacundiopus stylosus, Lambella cerina* and *Levonga papaitongensis* and the character state may be a synapomorphy for these species. They were described or redescribed by Manson (1984a). Tarsus I of *Levonga caseariasis* and *L. litseae* (Chakrabarti & Pandit, 1996; Chakrabarti *et al*., 1992, respectively), both from India, is apparently not divided, however, neither of the latter two species are particularly accurately described or depicted, and the real morphology is uncertain.

### 100. Leg I – tibia presence, or whether fused with tarsus:

0 = present
1 = partly fused to tarsus
2 = completely fused to tarsus (absent)

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 113, Character 21: 0 = normal; 1 = reduced or fused).

The character state scored for the following species, in particular, is ambiguous:

- *Lithocarus thomsoni*: legs of the genus *Lithocarus* are described in the text to be six segmented (no leg segments fused), further on in the same description (Chandrapatya & Boczek, 2000c), the measurement of a tibiotarsus in leg I was recorded for *L. thomsoni*, implicating that the tibia is fused with the tarsus in this species. In the descriptive drawing of *L. thomsoni*, however, the femur and genu are depicted as fused (genu absent). For the present study the tibia of this species is regarded to be present, separate from the tarsus.

### 101. Leg I – tibia length:

1 = short (2-3 micron)
2 = average (4-11 micron)
3 = medium long (12-13 micron)
4 = average long (14-15 micron)
5 = long (16-17 micron)
6 = very long (19-20 micron)
7 = very, very long (22 micron)

8 = exceptionally long (30 micron or more)

The tibial lengths were plotted on a graph. They essentially had a normal distribution (C. Craemer, *unpubl. data*). There were no particular large gaps between the lengths for allowing more objective determination of categories. The categories of lengths were determined by categorizing all the species with length within the standard deviation to be "average", and species with a tibial length lower or higher than "average" were divided into 2 µm increasing or decreasing categories as coded above. The length of the tibia of some species for which the length was not recorded, were usually deduced and scored from the descriptive drawing. The categories, and some lengths included, of this character are consequently subjective and probably ambiguous.

The character states scored for the following species, in particular, are ambiguous:

- The tibial length of leg I was not recorded, but was recorded for the tibia of leg II in *Lithocarus thomsoni* and *Diptilomiopus integrifoliae* (Chandrapatya & Boczek, 2000c; Mohanasundaram, 1981b, respectively). The tibial lengths of legs I and II seemed to be similar in the accompanying descriptive drawings, and it was extrapolated that the tibia of leg I is about the same length as that recorded for the tibia of leg II.
- Tibial length was not recorded for the following species, but in their descriptive drawings the tibiae seemed to be neither exceptionally long nor short, and their lengths were scored "average":

*Norma lanyuensis*
*Diptilomiopus alagarmalaiensis*
*D. aralioidus*
*Diptilomiopus camarae*
*D. commuiae*
*D. cumingis*
*D. cuminis* (redescription by Huang, 2001c)
*D. dendropanacis*
*D. elliptus*
*D. emarginatus*
*D. euryae*
*D. formosanus*
*D. hexogonus*
*D. leptophyllus*
*D. lobbianus*
*D. loropetali* (Kuang, 1986a; description in Chinese)
*D. maduraiensis* (length was recorded for "tibiotarsus")
*D. morii*
*D. octogonus*
*D. perfectus*
*D. stephanus*
*Prodiptilomiopus auriculatae*
*Sakthirhynchus canariae*
*Vasates quadripedes* (redescription by Keifer, 1959b)

*Levonga caseariasis*
*Norma lanyuensis*
*Aberoptus samoae*
*Cisaberoptus pretoriensis*
*Shevtchenkella juglandis*
*Fragariocoptes setiger*

**102. Leg I – tibial length in relation to tarsal length:**

0 = tibia shorter than half of tarsus length
1 = tibia shorter than tarsus, half or more of tarsus length
2 = tibia length equal to tarsus length
3 = tibia longer than tarsus, but less than half the length of tarsus longer
4 = tibia longer than tarsus, half or more, but less than twice the tarsus length
5 = tibia about twice as long as tarsus
6 = tibia exceptionally longer than tarsus (three or four times the tarsus length)

Relational data should ideally not be used for phylogenetic analyses (Thiele, 1993). It was decided to include this relational character, though, in an attempt to increase the number of characters, because it is used as such in many descriptions, and due to the explorative nature of the present study.

The character states scored for the following species, in particular, are ambiguous:

- Characteristics of leg I (including tibial and tarsal lengths) were not recorded for *Diptilomiopus integrifoliae*, and the measurements of leg II (Mohanasundaram, 1981b) were used for this character.
- The tarsal lengths were not recorded for *Aceria tulipae*, *Aculus ligustri* and *Catarhinus tricholaenae* in their original descriptions (Keifer, 1938a; 1959b), and the relation between the length of the tibia and tarsus was determined by measuring these segments on the descriptive drawings, and although these drawings by Keifer are reliable, they are semi-schematic and may be inaccurate for such detail.
- The tibial and tarsal lengths were not recorded for the following species, but were scored from the descriptive drawings, and the scoring is highly ambiguous, because it is not certain whether the drawings are accurate:

*Aberoptus samoae*
*Aceria tulipae*
*Catarhinus tricholaenae*
*Diphytoptus nephroideus*
*Diptilomiopus alagarmalaiensis*
*D. aralioidus*
*D. camarae*
*D. commuiae*
*D. cumingis*
*D. cuminis* (redescription by Huang, 2001c)
*D. dendropanacis*

*D. elliptus*
*D. emarginatus*
*D. euryae*
*D. formosanus*
*D. hexogonus*
*D. leptophyllus*
*D. lobbianus*
*D. loropetali* Kuang, 1986a (description in Chinese)
*D. maduraiensis* [length was recorded for "tibiotarsus" by Mohanasundaram (1986a)]
*D. morii*
*D. octogonus*
*D. perfectus*
*D. septimus*
*D. stephanus*
*Fragariocoptes setiger*
*Levonga caseariasis*
*Mediugum sanasaii*
*Neopropilus jatrophus*
*Norma lanyuensis*
*Pararhynacus photiniae*
*Phyllocoptruta oleivora* (redescription by Keifer, 1938a)
*Prodiptilomiopus auriculatae*
*Platyphytoptus sabinianae*
*Sakthirhynchus canariae*
*Setoptus jonesi*
*Shevtchenkella juglandis*
*Vasates quadripedes* (redescription by Keifer, 1959b)

### 103. Leg I – empodial shape (Fig. 3.6):

0 = pad-like with numerous rays (tenent rays or non-tenent rays or hair) (Fig. 4.1)
1 = simple (Fig. 3.6c, d)
2 = simple, distally elongated (Fig. 3.6e)
3 = simple, rays asymmetrical (more rays on one side than the other)
e.g., *Dechela epelis* (Fig. 3.6f)
4 = partly divided (Fig. 3.6g)
5 = divided (Fig. 3.6g)
6 = divided, stems unequal (Fig. 3.6i)
7 = divided, stems pad-like with numerous rays (Fig. 3.6j)
8 = divided, with central stem (Fig. 3.6k)
9 = palmate (Fig. 3.6l)
a = basal rays finely branched, hair-like (e.g., *Brevulacus reticulatus*) (Fig. 3.6m)
b = reduced to a bristle (Fig. 3.6n)
c = distal part splitting into six hairs, hairs not tenent shaped (Fig. 4.2)

This character was previously used in analyzing the phylogeny of the Eriophyoidea [Hong & Zhang, 1996a, p. 113, Character 24: 0 = simple (normal); 1 = not normal (divided, palm-shaped etc.)]. The shape of the empodium is used to differentiate Eriophyoidea taxa at the genus level, and sometimes at the subfamily level (e.g., Diptilomiopinae and Rhyncaphytoptinae). Taxa with divided empodia are present in all three Eriophyoidea families, and the character seems to be homoplasious.

The character state scored for the following species, in particular, is ambiguous:

- The empodium of *Diptilomiopus stephanus* was described as "divided" (Huang, 2005); however, in the accompanying drawing it seems that the two stems of the empodium may be pad-like (Huang, 2005). It was scored as being pad-like for the present study.

**104. Leg I – number of empodial rays:**

0 = numerous rays (can not count with ease)
1 = 16-rayed or more
2 = 11-12 rayed
3 = 10-rayed
4 = 9-rayed
5 = 8-rayed
6 = 7-rayed
7 = 6-rayed
8 = 5-rayed
9 = 4-rayed
a = 3-rayed
b = 2-rayed
c = reduced to a bristle (no rays)
d = six hairs splitting from one point

The number of empodial rays is extensively used to differentiate between Eriophyoidea species. It may vary within a species, and the character should be scored cautiously. Despite its own problems, it is relatively one of the clearer, easily observable and concise Eriophyoidea characters, though, and Meyer (*unpubl. data*) commenced with a key to the *Aceria* spp. of South Africa using the number of rays as the initial character to divide the genus into groups.

The character states scored for the following species, in particular, are ambiguous:

- The empodium of *Dechela epelis* is asymmetrical with the inside 5-rayed and the outside 7-rayed (Keifer, 1965a; Fig. 3.6f). To accommodate this difference in rays, ideally the number of empodial rays should be divided into two characters: the number of rays on the inner side of the empodium and the number of rays on the outer side of the empodium. This is usually not recorded in Eriophyoidea descriptions, though. The two states were coded as a polytomy in the present study. This is erroneous, but in my opinion a better option than scoring the code "?" (unknown).
- The number of rays on the empodium of *Acarhis lepisanthis* was described as "with 6-7 rays on outer fork and fewer on inner", in the accompanying drawing there seems to be about 2-3

rays on the inner branch and 7 rays on the outer branch (Keifer, 1975d; Fig. 3.6i). In the lateral view drawings this distinction between the inner and outer branch is not clearly depicted. The state was scored as polymorphic, namely 6 or 7 rays, because there is a slight chance that Keifer may have viewed the one branch dorsally and the other laterally. This is probably an erroneous interpretation by me and should be investigated.

- The empodium of *Diptilomiopus holmesi* was described by Keifer (1962c) as having about 6 rays, indicating that there is a variation in number of rays, or that he was not sure about the number. It was scored as 6-rayed.
- The empodium of *Diptilomiopus racemosae* was recorded as 6-rayed, however, in the descriptive drawing, the empodium is depicted with 7 rays (Chandrapatya & Boczek, 2001a). It was scored as 6-rayed.
- The number of empodial rays of the following species was not recorded in the text, and was counted on their descriptive drawings. Counting number of empodial rays on descriptive drawings may be very ambiguous, e.g., in *Chiangmaia longifolii* the number of empodial rays was recorded as 9, however, in the descriptive drawing of this species only 5 rays is depicted in the enlarged view of the empodium (Chandrapatya & Boczek, 2000c).

*Acarhis diospyrosis*
*Diptilomiopus aglaiae*
*D. anthocephaliae*
*D. artabotrysi* (one stem 5-rayed the other 6-rayed, coded as if it is a polymorphism – either 5- or 6-rayed)
*D. azadirachtae*
*D. barringtoniae*
*D. benjaminae*
*D. boueae*
*D. cerberae*
*D. cythereae*
*D. elaeocarpi*
*D. ervatamiae*
*D. eucalypti*
*D. languasi*
*D. melastomae*
*D. meliae*
*D. morindae*
*D. musae*
*D. pamithus*
*D. pocsi*
*D. riciniae*
*D. sandorici*
*D. strebli*
*D. swieteniae*
*D. thaianae*
*D. thunbergiae*
*Lambella cerina*
*Lithocarus thomsoni*

*Neolambella ligustri*
*Prodiptilomiopus auriculatae*
*Sakthirhynchus canariae*

**105. Leg II: femur and genu articulation – whether fused:**

0 = normally articulated
1 = division weak, almost fused
2 = not articulated, totally fused

The character state scored for the following species, in particular, is ambiguous:

- The legs of *Lithocarus* are described as being six segmented, however, in the descriptive drawing of *Lithocarus thomsoni*, the type species of the genus, the femur and genu are depicted as being fused (genu absent). For the present study, the genu and femur were scored as being totally fused.

**106. Leg II: tibia presence, or whether fused with tarsus:**

0 = present
1 = partly fused to tarsus
2 = completely fused to tarsus (absent)

The character state scored for the following species, in particular, is ambiguous:

- Similar problems found with *Lithocarus thomsoni* for Character 100 (presence of tibia in leg I) are also experienced with the presence of tibia in leg II, and the species was also scored here with the tibia present, separate from the tarsus.

## GENITALIA (Figs 3.4, 3.5)

Several of the characteristics of the Eriophyoidea genitalia are either hypothetically synapomorphic or are autapomorphic for the superfamily (Lindquist, 1996b) and some of these are included here. In general characters of the genitalia, particularly internal genitalia, are regarded to be informative regarding the phylogeny of groups. Internal genitalia are less exposed to the environment and therefore probably less influenced by environmental and niche changes. For example, characters of the genitalia are extensively used in the systematics of spiders (A.S. Dippenaar-Schoeman, *pers. comm.*). The internal genitalia of the Eriophyoidea vary significantly, but unfortunately, they are frequently difficult to study, because they are easily destroyed during slide-mounting of specimens, and can not be studied with the SEM. Even though the morphology of the internal genitalia of females are frequently briefly described (usually only the shape of the anterior apodeme), and depicted, the description of fine detail is not included. It is probably partly due to the extremely tiny size of these structures, which are obscured by other body structures. De Lillo *et al*. (2010) suggested that the genitalia should be dissected out of the body to be studied, but this is technically difficult and precise work. There are also many species for which character states of the internal genitalia are unknown, because they were, or could not be described. The external morphology and position of the genitalia of females, but not the males, are generally described and used in Eriophyoidea taxonomy.

***107. Post-larval instars – presence of genital acetabula:**

0 = with genital acetabula
1 = without genital acetabula

***108. Nymphal instar – presence of progenital opening and chamber:**

0 = with progenital opening and chamber
1 = without progenital opening and chamber

***109. Genital opening of female – presence of flap:**

0 = not covered by an anteriorly hinged flap
1 = covered by an anteriorly hinged flap

***110. Sperm transfer type:**

0 = with spermatophores deposited on substrate
1 = directly with aedeagus

***111. Aedeagus – presence:**

0 = present
1 = absent

**112. External genitalia – position:**

0 = caudally (Figs 4.1, 4.2)
1 = about 9-15 annuli removed from coxae, located posterior to *c2* (Fig. 3.5g)
2 = close to, but not appressed to coxae (Fig. 3.5d)
3 = appressed to coxae (Fig. 3.5a, b)

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 110, Character 11: 0 = not appressed to coxae II; 1 = appressed to coxae II).

This character is particularly of importance in defining the genus *Novophytoptus* (with the genitalia removed relatively far from the coxae) (Fig. 3.5g), and the subfamily Cecidophyinae (with the genitalia appressed against the coxae) (Fig. 3.5a, b). The position of the genitalia may be distorted by the slide-mounting process, for example the genitalia of *Cisaberoptus kenyae* are drawn against the coxae, and those of *C. pretoriensis*, slightly away. In this regard also compare Fig. 3.5a with 3.5b.

The character state scored for the following species, in particular, is ambiguous:

- *Cosella deleoni*: the genitalia were not described as being appressed against the coxae (a characteristic partly defining the Cecidophyinae) (Keifer, 1956). It is coded as appressed to the coxae, because the genitalia seems to be pressed up against the coxae in the descriptive drawing of the species, with no space or annuli between the genitalia and coxae II, with the genitalia partly situated between coxae II.

### **113. Female, internal genital apodeme – shape:**

0 = internal genital apodeme similar to that of the Eriophyoidea absent
1 = moderately extended to front ("normal") (Fig. 3.5e, i)
2 = folded up, appearing like a thick transverse line (Fig. 3.5c)
3 = folded up, but appearing slightly broader than a transverse line
4 = folded up, with special structure, consisting of about three transverse areas

The main diagnostic character of the subfamily Cecidophyinae is the shape of the internal female anterior genital apodeme which is folded up, appearing like a transverse line (Fig. 3.5c). However, if studied and compared in more detail, other characteristics of this apodeme also vary (e.g., although it is not a good example, compare Fig. 3.5c with 3.5f). In the present study the shape of this apodeme was scored "normal", except when otherwise noted or depicted, and even when the internal genitalia were not described or depicted, and especially when the external genitalia were not appressed to the coxae.

The character state scored for the following species, in particular, is ambiguous:

- *Aberoptus samoae*: the internal genitalia were not described nor depicted (Keifer, 1951), however, externally it looks very similar to those of *Cisaberoptus kenyae* (Keifer, 1966c) and it is presumed the internal genitalia of these two species may also be very similar, and in the present study they were scored to be the same.

### **114. Spermathecae – shape:**

0 = spermathecae similar to Eriophyoidea and Tetranychidae absent
1 = round or ovalish (Fig. 3.5c, e)
2 = elongated (Fig. 3.5f)

I find it notoriously difficult to see the spermathecae in the slide-mounted specimens of most species, and dissecting the genitalia from the body will probably help in studying them (as proposed by De Lillo *et al*., 2010, see above). The spermathecae of the Eriophyoidea are usually round (Fig. 3.5c, e) or slightly more oval. Among the species included in the present study, they are elongated in largely Phytoptidae species, [*Novophytoptus rostratae*, *N. stipae* (Novophytoptinae), *Acathrix trymatus*, *Anchiphytoptus lineatus*, *Oziella yuccae*, *Phytoptus avellanae* (Phytoptinae), *Austracus havrylenkonis*, *Sierraphytoptus alnivagrans* (Sierraphytoptinae)] (Roivainen, 1947; Keifer, 1962d; 1962c; 1952a; 1954; 1952b; 1944; 1939a, respectively) excluding the Nalepellinae. They are also elongated in *Africus psydraxae* (ambiguous) and *Apodiptacus cordiformis* (Diptilomiopinae) and *Ashieldophyes pennadamensis* (Ashieldophyinae) (Meyer & Ueckermann, 1995; Keifer, 1960; Mohanasundaram, 1984, respectively). The shape of the spermathecae of the latter three species is not exactly the same as the long spermathecae in the Phytoptidae, and they may not be homologous character states. It is detail like this that needs to be sorted out.

### **115. Spermathecal tube length:**

0 = spermathecal tubes similar to that in the Eriophyoidea and Tetranychidae absent
1 = relatively short to very short (normal) (Fig. 3.5c, e, f)
2 = long (Fig. 3.5i)

This character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 115, Character 32: 0 = long; 1 = short).

Long spermathecal tubes are present only in Nalepellinae species, and may be a synapomorphy for this subfamily (Lindquist & Amrine, 1996). They have also been depicted as elongated in *Pentasetacus araucaria* of this subfamily, but the tubes of the latter species is not the same shape as in the other Nalepellinae. It has been scored as “long” in the present study, though.

### **116. Female genital coverflap ornamentation:**

0 = absent
1 = entirely unornamented (Fig. 3.5h, g)
2 = entirely unornamented, but divided into a basal and distal area (e.g., *Hoderus roseus*)
3 = basally ornamented, distally unornamented (smooth)
4 = basally unornamented (smooth), distally ornamented
5 = entirely ornamented, divided in basal and distal area (possibly coverflap of *Cecidophyes* – Fig. 3.5a, b)
6 = entirely ornamented, not divided in basal and distal area (Fig. 3.5d)

A similar character was previously used in analyzing the phylogeny of the Eriophyoidea (Hong & Zhang, 1996a, p. 114, Character 26 (ridges of the female genital coverflap): 0 = absent; 1 = one longitudinal row; 2 = two longitudinal rows or transverse lines).

Characteristics of the external female genitalia are usually described and used in Eriophyoidea taxonomy. In particular the ornamentation on the female genital coverflap is extensively used in differentiating species. Detail of the type of ornamentation was not included in the data set of the present study. Defining characters and character states was attempted, but it turned out to be too ambiguous and uncertain, both in determining homologous areas of the coverflap (e.g., precisely determining the basal and distal area of the coverflap for comparison), and in the accuracy with which it was described. More detail of the ornamentation was, however, included in a parallel study of *Diptilomiopus* and closely related species (C. Craemer, *unpubl. data*).

For example, the distinction between an entirely ornamented genital flap, without distinction between a basal and distal area, and an entirely ornamented flap of which the ornamentation is divided between a basal and distal area, is not clear in published descriptions. For example, the coverflap ornamentation for *Costarectus zeyheri* is described as being “coverflap of gonopore with 11 longitudinal markings” (Meyer & Ueckermann, 1995), however, in the drawing it seems that there may be one or two transverse lines, of which the basal is centrally interrupted, basally to the longitudinal lines. This can be regarded as constituting a basal area, but although it has been depicted in this species, it has not been recorded in the text description. In the published descriptions of many other species with similar ornamentation, this basal area may not even be depicted. In the present study, *Costarectus zeyheri* was scored as entirely ornamented without a basal and distal area.

I will go as far as to suggest that many Eriophyoidea species descriptions where the genital coverflap was depicted, described and coded as entirely ornamented, but with the ornamentation not divided in a basal and distal area, may be inaccurate. In these species the ornamentation may be similar to e.g., *Costarectus zeyheri* (discussed above) and *Pentamerus rhamnicroceae* where there actually may be a basal area, but may be very thin and inconspicuous (descriptive drawing in Keifer, 1966a).

Many discrepancies and incorrect descriptive data regarding the shape and ornamentation of the female genital coverflap are present in the descriptions of Eriophyoidea species. The character states scored for the following species, in particular, are ambiguous:

- *Acarhis diospyrosis*: Chandrapatya & Boczek (1991c) described the ornamentation of the female genital coverflap as “genital coverflap with granules”, however, the exact area on which these granules occur, was not described. The area could not be determined from the descriptive drawing, because the granules can be on the basal area, or the flap could be pushed up and open, with granules on the entire area of the flap, however, according to the scanning electron images of the species it seems that the granules are only on the basal area. Unfortunately, the SEM images on the photocopied reprint are of very bad quality, and the original copies could not be obtained, and the state remains ambiguous.

- *Diphytoptus nephroideus*: the coverflap ornamentation was described as “about 7 short longitudinal lines” (Huang, 1991). The state was scored in the present study as “distally ornamented and basally smooth or unornamented”, because the lines are described as short, and it could be similar to that of *Davisella breitlowi* (Davis, 1964a), however, this could not be confirmed on the descriptive drawing, because the coverflap is distorted.
- *Quadriporca mangiferae*: the genital coverflap ornamentation could not be determined from the original Chinese description (Kuang *et al*., 1991). In the descriptive drawing a row of short longitudinal ridges is present, however, it can not be determined whether these ridges only occurs basally on the flap, or distally on the flap, since the flap is distorted and unclear. The ornamentation was scored to occur distally, similar to some of the other morphologically similar Rhyncaphytoptinae.
- *Diptilomiopus illicii*: the female genital flap ornamentation was described as “coverflap with basal faint lines and granules on either side” and was depicted as such in the descriptive drawing (Wei & Lu, 2001). Granules on the lateral areas of the coverflap is unusual, and do not occur in any other Eriophyoidea species. For the present study the state was scored as if ornamentation only occurs on the basal area.
- *Diptilomiopus loropetali*: the coverflap was described as “coverflap with a W-shaped design” (Kuang, 1986a). According to the shape and position of this ornamentation it seems that the author might have confused the interior apodemes and structures of the internal genitalia with ornamentation that may occur on the surface of the coverflap. The coverflap may be smooth, but for the present study, it was decided to stand with the author’s interpretation, and the coverflap ornamentation was scored as “present on the entire coverflap”.
- *Diptilomiopus phylanthi*: the coverflap was described as “coverflap with few longitudinal striae”, however, in the drawing some tubercles are depicted on the base of the coverflap (Boczek & Chandrapatya, 1992b).
- *Diptilomiopus swieteniae*: the coverflap was described as “smooth” (Chandrapatya & Boczek, 1998), however, in the descriptive drawing of the ventral aspect, the flap was clearly depicted ornamented with tubercles or granules, and in the lateral view drawing it seems to be smooth. For the present study it is scored as “entirely ornamented”.
- *Lambella cerina*: the coverflap was described as “smooth” (Lamb, 1953) in the original description. In the redescription by Manson (1984a) the coverflap was described as

ornamented "with fine granules", without reference to the state in the original description. The coverflap was scored "entirely ornamented" in the present study.

- *Vimola syzygii*: the coverflap ornamentation was described to be on the distal part of the flap (Boczek & Chandrapatya, 1992a); however, in the drawing it seems to be similar to the usual ornamentation which occurs basally on the coverflap. It was scored "basally ornamented, distally unornamented (smooth)" in the present study.
- *Keiferana neolitseae*: the coverflap ornamentation was described as "coverflap with no particular design" (Channabasavanna, 1967); however, in the drawing the ornamentation is strangely shaped and may include parts of the underlying internal genitalia. The shape and ornamentation of the flap is not clear. For the present study, the flap ornamentation is scored "entirely unornamented".

# Appendix C

List of characters included in analyses, with different character numbers as used in data matrices.

## APPENDIX C.

| | Character numbers | | |
|---|---|---|---|
| | 318tax set | 66tax set | 18tax set |
| Characters | | | |
| **GENERAL** | | | |
| *Immature stages: number of | 0 | | |
| *Respiratory: presence stigmata | 1 | | |
| *Excretory system: presence | 2 | | |
| **Muscles, cross-striated or smooth | 3 | | |
| **Tonofibrillary muscle attachments: presence | 4 | | |
| **Organs, basal membranes: presence | 5 | | |
| **CHAETOTAXY: General** | | | |
| *Immatures: what seta present | 6 | | |
| ***Setal morphology: presence actinopilin | 7 | | |
| **CHAETOTAXY: Gnathosomal setae** | | | |
| Palp seta _d_ : presence and shape | 8 | 0 | |
| *Palp tarsus: presence of solenidion | 9 | | |
| **CHAETOTAXY: Prodorsal setae** | | | |
| seta vi: presence | 10 | 1 | 0 |
| seta ve: presence | 11 | 2 | 1 |
| *Seta _sc2_ : presence | 12 | | |
| Seta _sc1_ (_sc_ in Eriophyoidea): presence | 13 | 3 | 3 |
| Seta _sc_ : length | 14 | 4 | 32 |
| Seta _sc_ , length relative to shield length | 15 | 5 | |
| Seta _sc_ , length relative to distance between them | | | |
| Scapular setal tubercle, presence and shape | 16 | 6 | 2 |
| Seta _sc_ and/or its tubercle, position | 17 | 7 | 6 |
| Seta _sc_ , direction of projection | 18 | 8 | 7 |
| **CHAETOTAXY: Opisthosomal setae** | | | |
| Seta _c1_ , presence | 19 | 9 | 11 |
| Seta _c2_ , presence | 20 | 10 | 24 |
| Setal tubercles _c2_ , presence | 21 | 11 | |
| Seta _d_ , presence | 22 | 12 | 12 |
| *seta _d_ , number of pairs present | 23 | | |
| *seta _d_ , position | 24 | | |
| seta e, presence | 25 | 13 | 13 |
| *seta e, number of pairs present | 26 | | |
| *seta e, position | 27 | | |
| *seta f, number of pairs present | 28 | | |
| *seta f, position | 29 | | |
| seta h1, presence | 30 | 14 | 30 |
| *seta ps, presence | 31 | | |
| **CHAETOTAXY: Coxisternal plate setae** | | | |
| seta 1b, presence | 32 | 15 | 14 |
| Setal tubercles _1b_ , presence | 33 | 16 | |
| _1b_ -_1b_ :_1a_ -_1a_ , relationship of distance between setae | 34 | 17 | |
| seta _1a_ , presence | 35 | | |
| Setal tubercle _1a_ , presence and shape | 36 | | |
| seta _1a_ , position in relation to seta 2a | 37 | 18 | 34 |
| seta _2a_ , presence | 38 | | |
| **CHAETOTAXY: seta associated with genitalia** | | | |
| *Genital setae, presence in adult | 39 | | |
| *Aggenital setae, presence | 40 | | |
| *Eugenital setae in female, presence | 41 | | |

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|---|---|---|---|
| *Eugenital setae in male, presence and shape | 42 | | |
| **CHAETOTAXY: Leg setae** | | | |
| Leg I femur, seta bv, presence | 43 | 19 | 15 |
| Leg I genu, seta l", presence | 44 | 20 | 16 |
| Leg I tibia, seta l', presence | 45 | 21 | 17 |
| Leg I tibia, seta l', position | 46 | 22 | |
| Leg I tibia, seta l', vertical position | 47 | 23 | |
| Leg I tibia, solenidion $\varphi$ , presence and position | 48 | 24 | 21 |
| Leg I tarsus, solenidion $\omega$ , position | 49 | 25 | |
| Leg II femur, seta bv, presence | 50 | 26 | 18 |
| Leg II genu, seta l", presence | 51 | 27 | 19 |
| Leg II tarsus, seta ft', presence | 52 | 28 | |
| **GNATHOSOMA** | | | |
| **Stylets additional to chelicerae, presence | 53 | | |
| **Cheliceral bases, presence of motivator | 54 | | |
| **Apical ends of palpi, shape | 55 | | |
| **Palpi, shape and position | 56 | | |
| Oral stylet: form | 57 | 29 | |
| Chelicerae: shape and position | 59 | 30 | 9 |
| **PRODORSUM: Prodorsal shield** | | | |
| Prodorsal shield: shape | 60 | 31 | |
| Ocelli or ocellar-like areas: presence, position, shape | 61 | | |
| Frontal lobe: presence and general shape | 62 | 32 | 4 |
| Frontal lobe: shape | 63 | 33 | |
| Frontal lobe apical edge: shape | 64 | 34 | |
| Frontal lobe, shield anterior edge: presence of spines | 65 | | 5 |
| Frontal lobe: presence of one slender filament | 66 | | |
| **PRODORSAL SHIELD ORNAMENTATION** | | | |
| Prodorsal shield ornamentation: presence | 67 | 35 | |
| **IDIOSOMA: General** | | | |
| *Lyrifissures: presence | 68 | | |
| *Opisthosoma rear end: shape in female | 69 | | |
| **IDIOSOMA: Opisthosoma shape, microtuberculation** | | | |
| Body: shape | 70 | 36 | 8 |
| *Opisthosomal annuli: presence | 71 | | |
| Opisthosomal annuli: dorsoventral differentiation | 72 | 37 | 27 |
| Dorsal annuli lateral extensions or lobes: presence, shape | 73 | 38 | 28 |
| Opisthosomal shape: presence ridges and furrows | 74 | 39 | 22 |
| "Telosomal" dorsal annuli: whether fused | 75 | 40 | |
| Dorsal annuli microtubercles: presence and position | 76 | 41 | 33 |
| **SECRETIONS** | | | |
| Wax secretion: presence | 77 | 42 | |
| Wax: type and secreting structures | 78 | 43 | |
| **LEGS, COXAE AND STERNAL AREA: General** | | | |
| *Larva legs III: presence | 79 | | |
| *Larva legs IV: presence | 80 | | |
| *Nymphal instar(s) legs III: presence | 81 | | |
| *Nymphal instar(s) legs IV: presence | 82 | | |
| *Adults legs III, presence | 83 | | |
| *Adults legs IV, presence | 84 | | |
| *Legs I true (paired) claws, presence | 85 | | |
| *Legs II true (paired) claws, presence | 86 | | |
| **Legs I empodia shape like "feather-claws", presence | 87 | | |
| **Legs II empodia shape like "feather-claws", presence | 88 | | |

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|---|---|---|---|
| *Coxisternal plates I medial separation, degree | 89 | | |
| *Coxisternal plates I seperation from coxisternal plates II | 90 | | |
| *Larva urstigmata, presence and position | 91 | | |
| **COXAE: Ornamentation and sternal area** | | | |
| Coxal plates I ornamentation, presence and degree | 92 | 44 | |
| Coxal plates II ornamentation, presence and degree | 93 | 45 | |
| Prosternal apodeme (sternal line), presence and shape | 94 | 46 | 29 |
| Coxal plates anterior edge, presence of four lobes | 95 | | |
| **LEGS (excluding coxae)** | | | |
| Leg tarsi, presence of shovel-shaped projections | 96 | | 26 |
| Leg I, femur and genu articulation | 97 | 47 | |
| Leg I, femur division | 98 | | |
| Leg I, tarsus division | 99 | | |
| Leg I tibia: presence as separate segment or degree of fusion | 100 | 48 | 20 |
| Leg I tibia, length | 101 | 49 | |
| Leg I tibia, length in relation to tarsus length | 102 | 50 | |
| Leg I empodium, shape | 103 | 51 | 23 |
| Leg I empodium, number of rays | 104 | 52 | |
| Leg II, femur and genu articulation | 105 | 53 | |
| Leg II, tibia, presence or degree of fusion | 106 | 54 | |
| **GENITALIA** | | | |
| *Acetabula in postlarval instars, presence | 107 | | |
| *Progenital opening and chamber in nymph, presence | 108 | | |
| *Genital opening of female, whether covered by flap | 109 | | |
| *Sperm transfer, whether with spermatophore or aedeagus | 110 | | |
| *Aedeagus, presence | 111 | | |
| Female genitalia: position | 112 | 55 | 10 |
| Female internal genital apodeme: shape | 113 | 56 | |
| Spermatheca: shape | 114 | 57 | |
| Spermathecal tube: length | 115 | 58 | 31 |
| Female genital coverflap: presence, division, ornamentation | 116 | 59 | 25 |

# APPENDIX D.

Data matrix for 318-taxon analyses. Data matrix of morphological characters for 316 eriophyoid species and two outgroup species (*Orphareptydeus* and *Mononychelus*) for the 318tax analyses. ? = uncertain or unknown character states, - = inapplicable states. Codes in light grey are of autapomorphic characters, codes in black and bold are homologous characters.

| 318-taxon data matrix | | | | | | | | | | | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456 |
| *Orfareptydeus stepheni* | 0000000100 | 0000330060 | 000?00?000 | 0000000000 | 0100000221 | 01000100–1 | -10--00000 | 00000010-0 | 1000000000 | 0034000000 | 0810000000 | 1100000 |
| *Mononychelus yemensis* | 1000000140 | 2000030060 | 0000000000 | 0000000-10 | 0120000100 | 00000000–0 | -00--00000 | 00000010-0 | 1000000000 | 0034000000 | 081cd00000 | 0000120 |
| *Abacarus acalyptus* | 21111111?1 | 2110331241 | 0101101111 | 0101101001 | 1110000522 | 0001121001 | 2122200411 | 6120110111 | 1111111111 | 1123310000 | 0231700111 | 1121116 |
| *Abacarus hystrix* | 2111111101 | 2110331241 | 0101101111 | 0101101001 | 1110000322 | 0001121001 | b122810411 | 6150110111 | 1111111111 | 1123310000 | 0231500111 | 1121116 |
| *Aberoptus samoae* | 21111111?1 | 2110331231 | 0101101111 | 2101201201 | 111001--23 | 0001121001 | 110--00411 | b1100110-1 | 1111111111 | 1100311300 | 0109c00111 | 1133116 |
| *Acadicrus bifurcatus* | 2111111101 | 2110331211 | 0101101111 | 2101101001 | 1110000522 | 0001121001 | 2121b00411 | 61500110-1 | 1111111111 | 1123310000 | 0341700111 | 1121113 |
| *Acalitus ledi* | 2111111141 | 2110331041 | 0101101111 | 2101301001 | 111101--22 | 0001121001 | a10--00411 | 31100110-1 | 1111111111 | 1123310000 | 0211800111 | 1121115 |
| *Acamina nolinae* | 2111111101 | 2110331011 | 0111111111 | 2101001101 | 1111000322 | 1001121001 | 2122600411 | 7150110111 | 1111111111 | 1100410000 | 0331800111 | 1121115 |
| *Acaphyllisa parindiae* | 2111111101 | 2110?41021 | 0101101111 | 2101101101 | 1110002022 | 0001121001 | 2122300411 | 71631100-1 | 1111111111 | 1113310000 | 0224a00111 | 1121115 |
| *Acarelliptus cocciformis* | 21111111?1 | 2110331011 | 0101101111 | 0101101001 | 1110000422 | 0001121001 | 2112200411 | 71621100-1 | 1111111111 | 1100310000 | 0211800111 | 1121116 |
| *Acarhis diospyrosis* | 21111111?1 | 2110551041 | 1201101111 | 2101001001 | 111111--22 | 1101121012 | 710--00411 | 51601100-1 | 1111111111 | 1100310100 | 0215810111 | 1121??3 |
| *Acarhis lepisanthis* | 2111111101 | 2110441011 | 1201101111 | 2101001001 | 1111100322 | 1101121012 | 1112600411 | 512011[12]0-1 | 1111111111 | 1111410000 | 0216[67]00111 | 1121113 |
| *Acarhis siamensis* | 2111111101 | 2110441011 | 1201101111 | 2101001101 | 1111100222 | 1101121012 | 110--00411 | 51601110-1 | 1111111111 | 1103210200 | 0205[45]20111 | 1121??5 |
| *Acarhynchus filamentus* | 2111111101 | 2110341011 | 0101101111 | 2101201201 | 1111000022 | 0001121012 | 2122101411 | 51601110-1 | 1111111111 | 1123310000 | 0237000111 | 1121113 |
| *Acaricalus segundus* | 2111111101 | 2110341011 | 0101101111 | 2101001001 | 1110000422 | 0001121001 | 7122100411 | 71201100-1 | 1111111111 | 1100210000 | 0225900111 | 1121115 |
| *Acathrix trymatus* | 2111111101 | 2010551200 | 0101101111 | 0101101101 | 1110000312 | 0001121001 | 210--00411 | 11100110-1 | 1111111111 | 1111310000 | 0221200111 | 1121211 |
| *Aceria tulipae* | 2111111101 | 2110211241 | 0101101111 | 0101001101 | 1110000422 | 0001121001 | 210--00411 | 11100110-1 | 1111111111 | 1123310000 | 0211600111 | 1121116 |
| *Acerimina cedrelae* | 2111111101 | 2110331241 | 0101101111 | 0112-01101 | 1110000422 | 0001121001 | 210--00411 | 11100110-1 | 1111111111 | 1100310000 | 0231900111 | 1121116 |
| *Achaetocoptes ajoensis* | 2111111101 | 2111--2--1 | 0101101111 | 2101101001 | 1110000322 | 0001121001 | d122200311 | 71731120-1 | 1111111111 | 1123310000 | 0221[56]00111 | 1132116 |
| *Acritonotus denmarki* | 2111111101 | 2110341211 | 0101101111 | 2101001001 | 1110000222 | 0001121001 | 2122100111 | 71821100-1 | 1111111111 | 1100310000 | 0549a00111 | 1121115 |
| *Aculodes mckenziei* | 2111111101 | 2110231241 | 0101101111 | 0101101101 | 1110000322 | 0001121001 | 2122400411 | 1110011171 | 1111111111 | 1123310000 | 0211600111 | 1121116 |
| *Aculops populivagrans* | 2111111101 | 2110331241 | 0101101111 | 2101201101 | 1110000522 | 0001121001 | 2122400311 | 61600120-1 | 1111111111 | 1123310000 | 0231900111 | 1121116 |
| *Aculus ligustri* | 2111111101 | 2110331241 | 0101101111 | 0101101001 | 1110000522 | 0001121001 | 2122220311 | 616001[02]0-1 | 1111111111 | 1120310000 | 0241900111 | 1121116 |
| *Acunda plectilis* | 2111111101 | 2110331241 | 0101101111 | 0101001101 | 1110000222 | 0001121001 | 210--00411 | 11401110-1 | 1111111111 | 1110310000 | 0211500111 | 1123116 |
| *Adenocolus psydraxi* | 2111111141 | 2110331241 | 0101101111 | 1101401001 | 111101--22 | 0001121001 | 2122100411 | 61600110-1 | 1111111111 | 1123510000 | 2–1[78]02111 | 1121111 |
| *Aequsomatus lanceolatae* | 2111111101 | 2110331011 | 0101101111 | 1112-01001 | 1110000622 | 0001121001 | 2122100411 | 61400120-1 | 1111111111 | 1113310000 | 0231a00111 | 1121??1 |
| *Africus psydraxae* | 2111111141 | 2110451021 | 1201101111 | 0112-13-01 | 111111--22 | 1111121012 | 110--00411 | 51201160-1 | 1111111111 | 1123210100 | 0215810111 | 1121213 |
| *Afromerus florinoxus* | 2111111101 | 2110331201 | 0101101111 | 2101201001 | 111001--22 | 0001121001 | 2122400411 | 11100110-1 | 1111111111 | 1100310000 | 0211700111 | 1132??6 |
| *Anchiphytoptus lineatus* | 21111111?1 | 2010331010 | 0101101111 | 0101101101 | 1110000312 | 0001121001 | 210--00411 | 111001b0-1 | 1111111111 | 1113310000 | 0231800111 | 1121213 |
| *Anothopoda johnstoni* | 21111111?1 | 2111--2--1 | 0101111111 | 2112-01001 | 111001--22 | 0001121001 | 210--00411 | 11100110-1 | 1111111111 | 1123510000 | 0101902111 | 1121113 |
| *Anthocoptes gutierreziae* | 2111111101 | 2110341241 | 0101101111 | 0101201101 | 1110000422 | 0001121001 | 3122200311 | 71730100-1 | 1111111111 | 1123310000 | 0221900111 | 1121115 |
| *Apodiptacus cordiformis* | 2111111101 | 2110331211 | 0101101111 | 2101001001 | 1111000422 | 1001121012 | 2122900411 | 7161110111 | 1111111111 | 1123410000 | 0335900111 | 1121215 |
| *Apontella bravaisiae* | 2111111101 | 2110341041 | 0101101111 | 2101001101 | 111101--22 | 0001121001 | 2112200311 | 71501120-1 | 1111111111 | 1123310000 | 1--1801111 | 1121??5 |
| *Arectus bidwillius* | 2111111101 | 2110331011 | 0101101111 | 0101001001 | 1111000522 | 0001121001 | 9122600411 | 51500190-1 | 1111111111 | 1123510000 | 0231700111 | 1121115 |
| *Areekulus eugeniae* | 2111111101 | 2110451021 | 0101101111 | 2101?01?01 | 1111001022 | 1111121012 | 1112100411 | a1501110-1 | 1111111111 | 11??210000 | 0341800111 | 112???1 |
| *Asetacus madronae* | 21111111?1 | 2111–10–1 | 0101101111 | 2101001101 | 1111000322 | 1001121012 | 9122700411 | 5120010141 | 1111111111 | 1120410000 | 0431700111 | 1121115 |
| *Asetadiptacus emiliae* | 21111111?1 | 2111–10–1 | 0101101111 | 1101101101 | 1111000322 | 1001121012 | 2112100411 | 51600110-1 | 1111111111 | 1123310000 | 0345800111 | 1121113 |
| *Asetilobus hodgkinsi* | 2111111101 | 2110331021 | 0101111111 | 2101301001 | 1110000322 | 0001121001 | 2122200411 | 51100110-1 | 1111111111 | 1123310000 | 0211[89]00111 | 1121?16 |
| *Ashieldophyes pennademensis* | 2111111101 | 2110552131 | 0111111111 | 0101201001 | 1110000322 | 0001121001 | 110--00111 | 91400100-1 | 1111111111 | 1100510000 | 0241900111 | 1131211 |
| *Austracus havrylenkonis* | 2111111101 | 2010331000 | 0101101111 | 0101101101 | 1110000412 | 0001121001 | 210--00111 | 21610100-1 | 1111111111 | 1100310000 | 0221900111 | 1121212 |
| *Baileyna marianae* | 2111111101 | 2110331241 | 0101101111 | 0101301001 | 1110000422 | 0001121001 | 210--00111 | 11501120-1 | 1111111111 | 1100310000 | 0211900111 | 1121115 |

| 318-taxon data matrix | | | | | | | | | | | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456 |
| *Bakeriella ocimis* | 2111111101 | 2110341251 | 0101101111 | 0101101101 | 1110000422 | 0001121001 | 2122800311 | 71601100-1 | 1111111111 | 1101310000 | 0221900111 | 1121116 |
| *Bariella farnei* | 2111111101 | 2111--2--1 | 0101101111 | 2101401001 | 1110000322 | 0001121001 | 2122600411 | 71601100-1 | 1111111111 | 1100310000 | 0221800111 | 1134115 |
| *Boczekella laricis* | 21111111?1 | 1111--2--0 | 0101101111 | 0101?01?01 | 111001--22 | 0001121001 | 210-200411 | 51501100-1 | 1111111111 | 1111310000 | 0221[56]00111 | 1121??1 |
| *Brachendus pumilae* | 2111111101 | 2110321201 | 0101101111 | 0101101001 | 1110000322 | 0001121001 | d111100411 | 11100110-1 | 1111111111 | 1123310000 | 0211800111 | 1123116 |
| *Brevulacus reticulatus* | 2111111101 | 2110333011 | 0101101111 | 0101101001 | 1110000623 | 0001121012 | 2122a00411 | 51601110-1 | 1111111111 | 1100310000 | 034ª000111 | 1121111 |
| *Bucculacus haweckii* | 2111111101 | 2110331011 | 0101101111 | 0101301001 | 1110000422 | 0001121012 | 2122200411 | 71601100-1 | 1111111111 | 1100310000 | 0235700111 | 1121??1 |
| *Calacarus pulviferus* | 2111111101 | 2111--2--1 | 0101101111 | 2101101101 | 1110000422 | 0101121001 | 2122100411 | 5120110121 | 1111111111 | 1123310000 | 0231900111 | 1121115 |
| *Calepitrimerus cariniferus* | 21111111?1 | 2110331221 | 0101101111 | 0101101001 | 1110000422 | 0001121001 | 2122200311 | 71511110-1 | 1111111111 | 1100310000 | 0221900111 | 1121116 |
| *Caliphytoptus quercilobatae* | 2111111101 | 2110331221 | 0101101111 | 0101101001 | 1110000422 | 0001121001 | 2122100411 | 71611100-1 | 1111111111 | 1100310000 | 0211800111 | 1121116 |
| *Caroloptes fagivagrans* | 21111111?1 | 2110331201 | 0101101111 | 0101101001 | 1110000522 | 0001121001 | 2112200311 | 71611100-1 | 1111111111 | 1123310000 | 0211900111 | 1121114 |
| *Catachella machaerii* | 2111111141 | 2110221241 | 0101101111 | 2101101001 | 111101--25 | 0001121001 | 2112200411 | 11200110-1 | 1111111111 | 1123510000 | 0211[345]00111 | 1121115 |
| *Catarhinus tricholaenae* | 21111111?1 | 2110341011 | 0101101111 | 2101101201 | 1111000023 | 0001121012 | 2122800311 | 71611110-1 | 1111111111 | 1123310000 | 0211700111 | 1121113 |
| *Cecidodectes euzonus* | 2111111101 | 2110331001 | 0111111111 | 2101201001 | 1110000422 | 0001121001 | 2122200111 | 31400100-1 | 1111111111 | 1100310000 | 0211800111 | 1122111 |
| *Cecidophyes rouhollahi* | 2111111101 | 2111--2--1 | 0101101111 | 2101301001 | 1110000322 | 0001121001 | 2112100411 | 51200110-1 | 1111111111 | 1110310000 | 0221800111 | 1132115 |
| *Cenaca syzygioidis* | 2111111141 | 2110321241 | 0101101111 | 2112-01001 | 111101--22 | 0001121001 | 210--00311 | 11100110-1 | 1111111111 | 1100310000 | 0111900111 | 1121116 |
| *Cenalox nyssae* | 2111111101 | 2110331251 | 0101101111 | 2101301001 | 1110000222 | 0001121001 | 2122400311 | 71501110-1 | 1111111111 | 1100210000 | 0211900111 | 1131111 |
| *Cercodes simondsi* | 2111111101 | 2110331201 | 0101101111 | 0101201001 | 1110000522 | 0001121001 | 210--00411 | 11802190-1 | 1111111111 | 1123310000 | 0211900111 | 1121116 |
| *Chakrabartiella ficusis* | 2111111101 | 2110331201 | 0101101111 | 0112-01001 | 1111000622 | 1001121012 | 110--00111 | 51501110-1 | 1111111111 | 1100310000 | 0231800111 | 1121114 |
| *Cheiracus sulcatus* | 2111111101 | 2110341251 | 0101101111 | 2101001001 | 1110001422 | 0001121012 | b122100411 | 71611100-1 | 1111111111 | 1123310000 | 0230000111 | 1121113 |
| *Chiangmaia longifolii* | 2111111101 | 2110451221 | 0101101111 | 1101101001 | 111101--22 | 1001121012 | 510--00411 | 51601130-1 | 1111111111 | 1120210000 | 0215400111 | 1123116 |
| *Chrecidus quercipodus* | 2111111101 | 2111--2--1 | 0101101111 | 2101201001 | 1110000322 | 0001121001 | 2122800411 | 51500100-1 | 1111111111 | 1120310000 | 0221700111 | 1132115 |
| *Circaces chakrabarti* | 2111111101 | 2110331241 | 0101101111 | 0101201001 | 1110000422 | 0001121001 | 210--00311 | 11810110-1 | 1111111111 | 1111310000 | 0211900111 | 1132116 |
| *Cisaberoptus kenyae* | 2111111101 | 2110331241 | 0101101111 | 2101301101 | 111001--22 | 0001121101 | f111c00111 | 71101110-1 | 1111111111 | 1100210200 | 1--1121111 | 1133116 |
| *Cisaberoptus pretoriensis* | 2111111101 | 2110331241 | 0101101111 | 1101101101 | 1110000422 | 0001121101 | 2121200111 | 71200190-1 | 1111111111 | 1100310000 | 0211600111 | 1121??1 |
| *Colomerus gardeniella* | 2111111101 | 2110331211 | 0101101111 | 2101301001 | 1110000422 | 0001121001 | 210--00411 | 11100110-1 | 1111111111 | 1100310000 | 0211800111 | 1132115 |
| *Colopodacus africanus* | 2111111101 | 2110341021 | 0101101111 | 2101301001 | 111001--22 | 0001121001 | 3122100411 | 61101110-1 | 1111111111 | 1100310000 | 2--1802111 | 1121113 |
| *Coptophylla lamimani* | 21111111?1 | 2111--2--1 | 0101101111 | 2101201001 | 1110000322 | 0001121001 | 2122200111 | 61610100-1 | 1111111111 | 1120310000 | 0221800111 | 1132116 |
| *Cosella deleoni* | 2111111101 | 2110341041 | 0101101111 | 2112-01001 | 111001--24 | 0001121001 | 2112900411 | 61400180-1 | 1111111111 | 1120510000 | 2--1802111 | 1131116 |
| *Cosetacus camelliae* | 2111111101 | 2110221241 | 0101101111 | 2101401001 | 111001--22 | 0001121001 | 210--00411 | 31100110-1 | 1111111111 | 1100310000 | 0211700111 | 1133115 |
| *Costarectus zeyheri* | 2111111101 | 2110331241 | 0101101111 | 0101101101 | 1110000522 | 0001121001 | 2122200411 | 6160110121 | 1111111111 | 1120310000 | 0241900111 | 1121116 |
| *Criotacus brachystegiae* | 2111111101 | 2110331201 | 0101101111 | 2101001101 | 1110000522 | 0001121001 | 2122800311 | 31400110-1 | 1111111111 | 1100310000 | 0221800111 | 1121111 |
| *Cupacarus cuprifestor* | 2111111101 | 2110331021 | 0101101111 | 0101001001 | 1110000222 | 0001121001 | d122800311 | 61601100-1 | 1111111111 | 1113210000 | 0221700111 | 1121113 |
| *Cymeda zealandica* | 2111111141 | 2110341021 | 0101101111 | 2101001001 | 111001--22 | 0001121001 | 2122100411 | 716001d131 | 1111111111 | 1100310020 | 0115800111 | 1121111 |
| *Cymoptus spiniventris* | 2111111101 | 2110331241 | 0101101111 | 2101301001 | 111001--22 | 0001121001 | 210--00411 | 11205100-1 | 1111111111 | 1100310000 | 0201b00111 | 1121?11 |
| *Dacundiopus stylosus* | 2111111141 | 2110451011 | 1201101111 | 2112-01001 | 111101--22 | 1101121012 | 910--00411 | 51601100-1 | 1111111111 | 1123520201 | 0215b20111 | 1121??1 |
| *Davisella breitlowi* | 21111111?1 | 2111–10–1 | 1201101111 | 2101101001 | 1111000322 | 1101121012 | 110--00411 | 51501110-1 | 1111111111 | 1100110000 | 0215800111 | 1121??4 |
| *Dechela epelis* | 2111111101 | 2111--2--1 | 0101101111 | 2112-01001 | 111001--25 | 0101121001 | 3112600411 | 31100110-1 | 1111111111 | 1123310000 | 0113[68]00111 | 1132116 |
| *Dialox stellatus* | 2111111101 | 2110551001 | 0101101111 | 1101001101 | 1111001422 | 0001121012 | c122a00411 | 5130011121 | 1111111111 | 1100310000 | 0865500111 | 1121116 |
| *Dichopelmus notus* | 2111111101 | 2110341241 | 0101101111 | 2101201001 | 1110000422 | 0001121001 | 2122250311 | 71610100-1 | 1111111111 | 1100310000 | 0234900111 | 1121??5 |
| *Dicrothrix anacardii* | 2111111121 | 2110341011 | 0111101111 | 2101001001 | 1110001622 | 0001121001 | 6122100411 | 71403100-1 | 1111111111 | 1100310000 | 0232900111 | 1121111 |
| *Diphytoptus nephroideus* | 2111111101 | 2110331241 | 0101101111 | 2101001101 | 1110000322 | 0101121001 | 210--00311 | 11100110-1 | 1111111111 | 1100310000 | 0235900111 | 1121114 |

| 318-taxon data matrix | | | | | | | | | | | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456 |
| *Diptacus pandanus* | 2111111101 | 2110451021 | 0101101111 | 0101101101 | 1111000322 | 0001121012 | 2122130111 | 71501100–1 | 1111111111 | 1123210000 | 0455500111 | 1121111 |
| *Diptacus sacramentae* | 2111111101 | 2110331211 | 0101101111 | 2101001101 | 1111000022 | 1001121012 | 2122100411 | 6160012121 | 1111111111 | 1111310000 | 0435700111 | 1121111 |
| *Diptilomiopus acronychia* | 21111111?1 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1101121012 | 110--00411 | 51501100–1 | 1111111111 | 1103310200 | 0215720111 | 1121111 |
| *D. aglaiae* | 2111111141 | 2111–10–1 | 1201101111 | 1112–01101 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123510200 | 0215720111 | 1121116 |
| *D. alagarmalaiensis* | 2111111101 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 110--00411 | 51500110–1 | 1111111111 | 1103210200 | 0105920111 | 1121113 |
| *D. alangii* | 2111111101 | 2111--2--1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1100310200 | 0215720111 | 1121111 |
| *D. anthocephaliae* | 2111111101 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123310200 | 0215820111 | 1121113 |
| *D. aralioidus* | 2111111101 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1101121012 | 210--00411 | 51500100–1 | 1111111111 | 1100510200 | 0205820111 | 1121111 |
| *D. artabotrysi* | 2111111101 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123210200 | 0215[78]20111 | 1121113 |
| *D. artocarpae* | 2111111101 | 2111–10–1 | 1201101111 | 1112–01001 | 111101--22 | 1101121012 | 110--00411 | 7150110151 | 1111111111 | 1123310000 | 0255800111 | 1121115 |
| *D. asperis* | 2111111101 | 2111–10–1 | 1201101111 | 2112–01101 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1100310200 | 0215720111 | 1121111 |
| *D. assamica* | 21111111?1 | 2111–10–1 | 1201101111 | 2112–01101 | 111111--22 | 1111121012 | 2111100411 | 51501100–1 | 1111111111 | 1123310200 | 0215820111 | 1121111 |
| *D. averrhoae* | 21111111?1 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1101121012 | 110--00411 | 51501100–1 | 1111111111 | 1120310200 | 0215520111 | 1121111 |
| *D. azadirachtae* | 2111111141 | 2111–10–1 | 1201101111 | 2112–01101 | 111101--22 | 1111121012 | 110--00411 | 515011?0–1 | 1111111111 | 1123310200 | 0225920111 | 1121111 |
| *D. barringtoniae* | 2111111101 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1111121012 | 210--00411 | 51501100–1 | 1111111111 | 1123310200 | 0225720111 | 1121113 |
| *D. bengalensis* | 2111111141 | 2111--2--1 | 1201101111 | 2112–01001 | 111?11--22 | 0101121012 | 210--00411 | 51501100–1 | 1111111111 | 1100210000 | 0215700111 | 1121111 |
| *D. benjaminae* | 2111111141 | 2111–10–1 | 1201101111 | 1112–01101 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123310200 | 0215620111 | 1121111 |
| *D. boueae* | 2111111101 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123510200 | 0215820111 | 1121111 |
| *D. camarae* | 2111111101 | 2111–10–1 | 1201101111 | [12]112–01001 | 111111--22 | 1111121012 | 110--00411 | 61501170–1 | 1111111111 | 1123510200 | 0215720111 | 1121113 |
| *D. cerberae* | 2111111141 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123310200 | 0225720111 | 1121111 |
| *D. championi* | 21111111?1 | 2111--2--1 | 1201101111 | 2112–01?01 | 111?????22 | ???1121012 | 710--00411 | 51501100–1 | 1111111111 | 11???10??? | 0??55?0111 | 1121111 |
| *D. cocculae* | 21111111?1 | 2111–10–1 | 1201101111 | 2112–01101 | 111111--22 | 1101121012 | 210--00411 | 51501110–1 | 1111111111 | 1120310200 | 0215620111 | 1121113 |
| *D. combretae* | 2111111141 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1101121012 | 110--00411 | 51501100–1 | 1111111111 | 1100210200 | 0205720111 | 1121113 |
| *D. combreti* | 21111111?1 | 2111--2--1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 4111–00411 | 51501100–1 | 1111111111 | 1123310200 | 0105720111 | 1121113 |
| *D. commuiae* | 21111111?1 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 410–200411 | 51501100–1 | 1111111111 | 1120310200 | 0225620111 | 1121116 |
| *D. coreiae* | 2111111101 | 2111–10–1 | 1201101111 | 1112–02101 | 111111--22 | 1111121012 | 110--00411 | 51501130–1 | 1111111111 | 1120310200 | 0215720111 | 1121116 |
| *D. cumingis* | 21111111?1 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 2111600411 | 51501100–1 | 1111111111 | 1100310200 | 0215620111 | 1121116 |
| *D. cuminis* | 2111111101 | 2111–10–1 | 1201101111 | 2112–01101 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123310200 | 0215720111 | 1121111 |
| *D. cuminis Huang* | 21111111?1 | 2111--2--1 | 1201101111 | 2112–01001 | 1111100022 | 1101121012 | 1111100411 | 51501100–1 | 1111111111 | 1100310200 | 0215720111 | 1121111 |
| *D. cythereae* | 21111111?1 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1111121012 | 210--00411 | 51501110–1 | 1111111111 | 1122310200 | 0215720111 | 1121113 |
| *D. davisi* | 2111111141 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1111121012 | 410--00411 | 51501180–1 | 1111111111 | 1111210200 | 0205720111 | 1121113 |
| *D. dendropanacis* | 21111111?1 | 2111--2--1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 210--00411 | 51501100–1 | 1111111111 | 1123310200 | 0215720111 | 1121113 |
| *D. elaeocarpi* | 2111111101 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123310200 | 0215720111 | 1121113 |
| *D. elliptus* | 21111111?1 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1120310200 | 0215720111 | 1121111 |
| *D. emarginatus* | 21111111?1 | 2111--2--1 | 1201101111 | 2112–01001 | 111111--22 | 1101121012 | 4111100411 | 51501100–1 | 1111111111 | 1100310200 | 0215420111 | 1121111 |
| *D. ervatamiae* | 2111111101 | 2111–10–1 | 1201101111 | 2101111101 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1100310200 | 0215720111 | 1121113 |
| *D. eucalypti* | 2111111101 | 2111–10–1 | 1201101111 | 2112–01101 | 111111--22 | 1111121012 | 110--00411 | 51501110–1 | 1111111111 | 1123310200 | 0215720111 | 1121113 |
| *D. euryae* | 21111111?1 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1101121012 | 110--00411 | 5150?100–1 | 1111111111 | 1103310200 | 0215420111 | 1121111 |
| *D. ficifolius* | 21111111?1 | 2111--2--1 | 1201101111 | ?112–01101 | 111111--22 | 1101121012 | 110--00411 | 51501100–1 | 1111111111 | 1100310200 | 0225520111 | 1121111 |
| *D. ficus* | 2111111101 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501110–1 | 1111111111 | 1123310200 | 0215520111 | 1121113 |
| *D. ficusis* | 2111111101 | 2111--2--1 | 1201101111 | 2112–01001 | 111111--22 | 1101121012 | 110--00411 | 51501100–1 | 1111111111 | 1112310200 | 0215620111 | 1121115 |

| 318-taxon data matrix | | | | | | | | | | | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| | 0123456789 | 0123456789 | 0123456789 | 01234**5**6789 | 0123456789 | 0123456**789** | 0123456789 | 01234**5**6789 | 0123456789 | 012345678**9** | 0123456789 | 0123456 |
| *D. formosanus* | 21111111?1 | 2111––2––1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1101121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 110031020**0** | 0215820111 | 1121111 |
| *D. gilibertiae* | 2111111141 | 2111—10–1 | 1201101111 | 1112–**0**1101 | 111111––22 | 1111121**012** | 210––00411 | 51501**1**10–1 | 1111111111 | 112331020**0** | 0215720111 | 1121113 |
| *D. guajavae* | 2111111101 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111101––22 | 1111121**012** | 110––00411 | 51500**1**?0–1 | 1111111111 | 110321000**0** | 2––5702111 | 1121111 |
| *D. hexogonus* | 21111111?1 | 2111––2––1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1101121**012** | 1111100411 | 51501**1**00–1 | 1111111111 | 110031020**0** | 0245520111 | 1121111 |
| *D. holmesi* | 21111111?1 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 410––00411 | 51501**1**10–1 | 1111111111 | 112331020**0** | 0215720111 | 1121113 |
| *D. holopteleae* | 2111111101 | 2111––2––1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 110031020**0** | 0235820111 | 112111 [16] |
| *D. holoptelus* | 2111111101 | 2111—10–1 | 1201101111 | 2112–**0**1101 | 111111––22 | 1101121**012** | 410––00411 | 51501**1**00–1 | 1111111111 | 112331020**0** | 0215620111 | 112111 [16] |
| *D. illicii* | 21111111?1 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1101121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112331020**0** | 0215520111 | 1121113 |
| *D. indicus* | 21111111?1 | 2111––2––1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1101121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 110031020**0** | 0115620111 | 1121114 |
| *D. integrifoliae* | 21111111?1 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51511**1**00–1 | 1111111111 | 112251020**0** | 0235820111 | 1121113 |
| *D. jasminiae* | 2111111101 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112331020**0** | 0215720111 | 1121116 |
| *D. javanicus* | 21111111?1 | 2111––??–1 | 1201101111 | 21???**0**1?01 | 111111––2? | 1111121**012** | ?1???00411 | 51501**1**00–1 | 1111111111 | 11???1020**0** | 0?15720111 | 1121111 |
| *D. jevremovici* | 21111111?1 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 210––00411 | 51501**1**60–1 | 1111111111 | 112331020**0** | 0215720111 | 1121115 |
| *D. knorri* | 2111111141 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 1111600411 | 51501**1**70–1 | 1111111111 | 110321010**0** | 0215810111 | 1121113 |
| *D. languasi* | 2111111101 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112331020**0** | 0235720111 | 1121113 |
| *D. leeasis* | 2111111101 | 2111—10–1 | 1101101111 | 2112–**0**1101 | 111111––22 | 1111121**012** | 110––00411 | 51500**1**00–1 | 1111111111 | 112331020**0** | 0215820111 | 1121111 |
| *D. leptophyllus* | 21111111?1 | 2111––2––1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1101121**012** | 2111100411 | 51501**1**00–1 | 1111111111 | 110031020**0** | 0225720111 | 1121111 |
| *D. lobbianus* | 21111111?1 | 2111––2––1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1101121**012** | 1111100411 | 51200**1**00–1 | 1111111111 | 110031020**0** | 0235920111 | 1121116 |
| *D. loropetali* | 21111111?1 | 2111—10–1 | 1201101111 | 1112–**0**1101 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**10–1 | 1111111111 | 112331020**0** | 0215420111 | 1121113 |
| *D. maduraiensis* | 2111111101 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51500**1**00–1 | 1111111111 | 110021020**0** | 0205820111 | 1121113 |
| *D. malloti* | 21111111?1 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1101121**012** | 210––00411 | 51500**1**10–1 | 1111111111 | 112331020**0** | 0215720111 | 1121116 |
| *D. melastomae* | 2111111101 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 1111900411 | 51501**1**3141 | 1111111111 | 112351020**0** | 0205620111 | 1121111 |
| *D. meliae* | 2111111141 | 2111—10–1 | 1201101111 | 2112–**0**1101 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**10–1 | 1111111111 | 112331020**0** | 0215820111 | 1121111 |
| *D. morii* | 21111111?1 | 2111––2––1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1101121**012** | 1111800411 | 51500**1**10–1 | 1111111111 | 110031020**0** | 0215720111 | 1121111 |
| *D. morindae* | 21111111?1 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112331020**0** | 0215820111 | 1121113 |
| *D. musae* | 2111111141 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1101121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112231020**0** | 0215920111 | 1121113 |
| *D. octogonus* | 21111111?1 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1101121**012** | 1111100411 | 51501**1**00–1 | 1111111111 | 112331020**0** | 0215620111 | 1121113 |
| *D. pamithus* | 21111111?1 | 2111—10–1 | 1201101111 | 2112–**0**1101 | 111111––22 | 1101121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112031020**0** | 0105720111 | 1121111 |
| *D. perfectus* | 21111111?1 | 2111––2––1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1101121**012** | 1111200411 | 51501**1**00–1 | 1111111111 | 110031020**0** | 0215820111 | 1121113 |
| *D. phylanthi* | 21111111?1 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112331020**0** | 0215?20111 | 1121111 |
| *D. pocsi* | 21111111?1 | 2111––2––1 | 1201101111 | 2112–**0**1001 | 11111???22 | 1111121**012** | 210––00411 | 51501**1**10–1 | 1111111111 | 112331020**0** | 0215720111 | 1121116 |
| *D. racemosae* | 2111111141 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112321020**0** | 0215720111 | 1121116 |
| *D. riciniae* | 2111111101 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**10–1 | 1111111111 | 112321020**0** | 0205620111 | 1121113 |
| *D. sandorici* | 2111111101 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 11111???22 | 1111121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 112231020**0** | 0205820111 | 1121113 |
| *D. securinegus* | 21111111?1 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 110––00411 | 51501**1**60–1 | 1111111111 | 112321020**0** | 0215?20111 | 1121116 |
| *D. septimus* | 21111111?1 | 2111––2––1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1101121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 110031020**0** | 0215420111 | 1121113 |
| *D. apolongus* sp. nov. | 2111111141 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 1121600411 | 51501**1**60–1 | 1111111111 | 112331020**0** | 0215 [56] 20111 | 1121113 |
| *D. apobrevus* sp. nov. | 2111111141 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 1121600411 | 51501**1**60–1 | 1111111111 | 112351020**0** | 0215 [56] 20111 | 1121113 |
| *D. faurius* sp. nov. | 2111111141 | 2111—10–1 | 1201101111 | 1112–**0**1001 | 111111––22 | 1111121**012** | 1121600411 | 51501**1**60–1 | 1111111111 | 112331020**0** | 0215 [56] 20111 | 1121116 |
| *D. stephanus* | 21111111?1 | 2111––2––1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 1111200411 | 51501**1**40–1 | 1111111111 | 110031020**0** | 0217220111 | 1121111 |
| *D. strebli* | 21111111?1 | 2111—10–1 | 1201101111 | 2112–**0**1001 | 111111––22 | 1111121**012** | 410––00411 | 51501**1**00–1 | 1111111111 | 112331020**0** | 0215720111 | 1121116 |

| 318-taxon data matrix | | | | | | | | | | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456 |
| *D. swieteniae* | 2111111141 | 2111–10–1 | 1201101111 | 2112–01101 | 111111--22 | 1111121012 | 110--00411 | 51501110–1 | 1111111111 | 1123310200 | 0215920111 | 1121113 |
| *D. thaianae* | 2111111101 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501110–1 | 1111111111 | 1123210200 | 0215820111 | 1121115 |
| *D. thangaveli* | 21111111?1 | 2111–10–1 | 1201101111 | 1112–01001 | 111101--22 | 1111121012 | 210--00411 | 51500110–1 | 1111111111 | 1100210000 | 0215800111 | 1121113 |
| *D. thunbergiae* | 2111111101 | 2111–10–1 | 1201101111 | 1112–01001 | 111111--22 | 1111121012 | 110--00411 | 51501100–1 | 1111111111 | 1123310200 | 0205620111 | 1121111 |
| *D. trewier* | 2111111101 | 2111--2--1 | 1201101111 | 2112–01001 | 111111--22 | 1101121012 | 4111100411 | 51501100–1 | 1111111111 | 1123310200 | 0215820111 | 1121115 |
| *D. ulmivagrans* | 2111111101 | 2111–10–1 | 1201101111 | 1112–01001 | 111101--22 | 1101121012 | 110--00411 | 51501100–1 | 1111111111 | 1100210000 | 0205 [56] 00111 | 1121111 |
| *Diptiloplatus megagrastis* | 2111111101 | 2110451021 | 0101101111 | 2101201101 | 1111001022 | 0101121012 | 2122200311 | 71601120–1 | 1111111111 | 1123210000 | 0238700111 | 1121113 |
| *Diptilorhynacus dioscoreae* | 2111111101 | 2111–10–1 | 1201101111 | 2112–01001 | 111111--22 | 1111121012 | 610--00411 | 51501100–1 | 1111111111 | 1120210200 | 0215620111 | 1121113 |
| *Diptilorhynacus sinusetus* | 2111111101 | 2111--2--1 | 1211101111 | 0112–01001 | 111111--22 | 1101121012 | 910--00411 | 51501100–1 | 1111111111 | 1103210000 | 0215600111 | 1121116 |
| *Diptilostatus nudipalpus* | 2111111141 | 2111–10–1 | 0101101111 | 1101101001 | 111101--22 | 1101121012 | 110--00411 | 51501120–1 | 1111111111 | 1123510000 | 0205800111 | 1121115 |
| *Disella ilicis* | 2111111101 | 2110331051 | 0101101111 | 1112–01001 | 111001--24 | 0001121001 | 2122100411 | 51511100–1 | 1111111111 | 1100310000 | 1--1801111 | 1121115 |
| *Ditrymacus athiasella* | 2111111101 | 2110341241 | 0101101111 | 0101201101 | 1110001622 | 0001121001 | 2122100311 | 71631100–1 | 1111111111 | 1100310000 | 0231900111 | 1121115 |
| *Duabangus chiangmai* | 2111111101 | 2110331111 | 0101101111 | 2101001101 | 111101--22 | 1001121012 | 410--00411 | 5150113121 | 1111111111 | 1100310000 | 0235 [456] 00111 | 1121??3 |
| *Ectomerus anysis* | 2111111101 | 2110331201 | 0101101111 | 2101301001 | 1110000422 | 0001121001 | 2222800411 | 11100110–1 | 1111111111 | 1120310000 | 0211800111 | 1132115 |
| *Epicecidophyes clerodendris* | 2111111101 | 2110341021 | 0101101111 | 2101001001 | 1110000322 | 0101121001 | 2122100311 | 51621100–1 | 1111111111 | 1100310000 | 0231800111 | 1133116 |
| *Epiphytimerus palampurensis* | 2111111101 | 2110341241 | 0101101111 | 0101101001 | 1110000422 | 0001121001 | 2122900411 | 71621110–1 | 1111111111 | 1100310000 | 0241900111 | 1121116 |
| *Epitrimerus pyri* | 2111111101 | 2110331021 | 0101101111 | 0101001001 | 1110000422 | 0001121001 | 2122200411 | 71601110–1 | 1111111111 | 1123310000 | 0221900111 | 1121116 |
| *Eriophyes pyri* | 2111111101 | 2110221201 | 0101101111 | 0101101001 | 1110000322 | 0001121001 | 610--00411 | 31100110–1 | 1111111111 | 1121510000 | 0211900111 | 1121?16 |
| *Eriophyes quadrifidus* | 2111111101 | 2110331021 | 0101101111 | 0101201001 | 1110000422 | 0001121001 | 2122100411 | 11100110–1 | 1111111111 | 1123310000 | 0231900111 | 1121115 |
| *Euterpia fissa* | 2111111121 | 2110341031 | 0111111111 | 2101001001 | 1111000222 | 1001121001 | 6122100411 | 81201100–1 | 1111111111 | 1100310000 | 0111a00111 | 112???? |
| *Floracarus calonyctionis* | 2111111101 | 2110331241 | 0101101111 | 2112–01001 | 111001--24 | 0001121001 | 2122100411 | 61100110–1 | 1111111111 | 1123510000 | 2--1902111 | 1121115 |
| *Fragariocoptes setiger* | 2111111101 | 20103410 [014] | 0010110111 | 1010110100 | 1111000042 | 2000112100 | 1212220041 | 1 [67] 1500120– | 1111111111 | 1110031000 | 0022190011 | 11121??6 |
| *Gammaphytoptus camphorae* | 2111111101 | 2110231241 | 0101101111 | 2101301001 | 1110000422 | 0001121001 | 2122100411 | 51615110–1 | 1111111111 | 1110510000 | 0221700111 | 1132115 |
| *Glyptacus lithocarpi* | 21111111?1 | 2111--2--1 | 0101101111 | 2101201001 | 1110000322 | 0001121001 | 2122100411 | 61511110–1 | 1111111111 | 1110310000 | 0211600111 | 1132116 |
| *Heterotergum gossypii* | 2111111101 | 2110221241 | 0101101111 | 0101201001 | 1110000422 | 0001121001 | 2122400311 | 61620110–1 | 1111111111 | 1120310000 | 0221800111 | 1121115 |
| *Hyboderus roseus* | 2111111101 | 2110341101 | 0101101111 | 0101001101 | 1111000422 | 1101121012 | 610--00311 | 51600100–1 | 1111111111 | 1112310000 | 0231 [67] 00111 | 1121112 |
| *Hyborhinus kallarensis* | 2111111101 | 2110331101 | 0101101111 | 0112–01001 | 1110002422 | 0001121012 | 610--00411 | 51610160–1 | 1111111111 | 1100310000 | 0441600111 | 1121111 |
| *Indonotolox sudarsani* | 2111111101 | 2110331001 | 0101101111 | 0112–01001 | 111001--22 | 0001121001 | 2122100411 | a1401100–1 | 1111111111 | 1100310000 | 0231700111 | 1121111 |
| *Indosetacus rhinacanthi* | 2111111101 | 2110331241 | 0101101111 | 0101401001 | 1110000422 | 0001121001 | 210--00411 | 11800190–1 | 1111111111 | 1123310000 | 0111900111 | 1132111 |
| *Indotegolophus darjeelingensis* | 2111111101 | 2110331241 | 0101101111 | 2101401001 | 1110000522 | 0001121001 | 210--00411 | 51801110–1 | 1111111111 | 1123310000 | 0221700111 | 1121116 |
| *Johnella virginiana* | 21111111?1 | 2111--2--1 | 0101101111 | 2101201001 | 1110000422 | 0001121001 | 2122200311 | 71730100–1 | 1111111111 | 1110310000 | 0211600111 | 1132115 |
| *Jutarus benjaminae* | 2111111101 | 2111--2--1 | 0101101111 | 2112–01001 | 1110000222 | 0101121001 | 1122700411 | 51500110–1 | 1111111111 | 1110310000 | 0211900111 | 1121??3 |
| *Kaella flacourtiae* | 2111111141 | 2111–10–1 | 1201111111 | 1112–02101 | 111101--22 | 1101121012 | 110--00411 | 51501100–1 | 1111111111 | 1122210000 | 0205600111 | 1121??6 |
| *Keiferana neolitseae* | 2111111101 | 2110341241 | 0101101111 | 2101201001 | 1110000122 | 0001121001 | 2122300411 | 6140010141 | 1111111111 | 1103310000 | 0351800111 | 1121??1 |
| *Keiferella juniperici* | 21111111?1 | 2110341011 | 0101101111 | 0101001101 | 1110000322 | 0001121001 | 2133–00411 | 51301100–1 | 1111111111 | 1100310000 | 0431600111 | 1121??5 |
| *Keiferophyes avicenniae* | 2111111101 | 2110331241 | 0101101111 | 0101201001 | 1110000422 | 0001121001 | 210--00411 | 11100110–1 | 1111111111 | 1123310000 | 0231800111 | 1123116 |
| *Knorella gigantochloae* | 2111111141 | 2111--2--1 | 0111111111 | 2101001001 | 1111000322 | 1101121001 | 8122800411 | 81671100–1 | 1111111111 | 1123310000 | 0215800111 | 1121113 |
| *Konola hibernalis* | 2111111101 | 2110331211 | 0101101111 | 2101201001 | 1111000422 | 1001121012 | a122a00411 | 6120116171 | 1111111111 | 1100210000 | 0231600111 | 1123115 |
| *Lambella cerina* | 2111111141 | 2110341111 | 1201101111 | 2112–01001 | 111111--22 | 1101121012 | 910--00411 | 5160110111 | 1111111111 | 1120510001 | 0215700111 | 1121116 |
| *Latinotus wegoreki* | 2111111101 | 2110341201 | 0101101111 | 0101101001 | 1110000222 | 0001121001 | 2122100411 | 71601100–1 | 1111111111 | 1100310000 | 0241800111 | 1121116 |
| *Leipothrix solidaginis* | 2111111121 | 2110341021 | 0101101111 | 0101001201 | 1111000522 | 1001121001 | 2122200411 | 61601110–1 | 1111111111 | 1123310000 | 0231900111 | 1121115 |

| 318-taxon data matrix | | | | | | | | | | | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456 |
| *Levonga caseariasis* | 2111111101 | 2110441011 | 1201101111 | 2112–01101 | 111101--22 | 1101121012 | 110--00411 | 51601100–1 | 1111111111 | 1100210000 | 0215400111 | 1121?11 |
| *Levonga litseae* | 2111111101 | 2110441011 | 1201101111 | 2112–01001 | 111101--22 | 1111121012 | 110--00411 | 51100110–1 | 1111111111 | 1123210000 | 0215600111 | 1121113 |
| *Levonga papaitongensis* | 2111111101 | 2110451021 | 1201101111 | 0112–01001 | 111101--22 | 1101121012 | 210--00411 | 5160010141 | 1111111111 | 1120510001 | 0215800111 | 1121??1 |
| *Litaculus khandus* | 2111111101 | 2110331011 | 0101101111 | 2101101001 | 1110000422 | 0101121001 | 2122300411 | 61620100–1 | 1111111111 | 1100310000 | 0215700111 | 1121?15 |
| *Lithocarus thomsoni* | 2111111101 | 2110441011 | 1201101111 | 1101001001 | 111111--22 | 1101121012 | 410--00411 | 51601140–1 | 1111111111 | 1110210200 | 0105620111 | 1121116 |
| *Mackiella phoenicis* | 2111111101 | 2010331001 | 0101101111 | 0101301301 | 1110000412 | 0001121001 | 2122600411 | 116001b0–1 | 1111111111 | 1100310000 | 0231600111 | 1121?11 |
| *Mediugum sanasaii* | 21111111?1 | 2110441041 | 1201111111 | 0101101001 | 111111--22 | 1101121012 | 112--00411 | 51500140–1 | 1111111111 | 1100210200 | 0?05620111 | 1121??3 |
| *Mesalox tuttlei* | 2111111101 | 2110331241 | 0101101111 | 2101001101 | 1110000422 | 0001121001 | 2122800411 | 61611100–1 | 1111111111 | 1123310000 | 0221900111 | 1121115 |
| *Metaculus syzygii* | 2111111101 | 2110341241 | 0101101111 | 1112–01001 | 1110000522 | 0001121001 | 2122300311 | 71610110–1 | 1111111111 | 1123310000 | 0231900111 | 1121115 |
| *Metaplatyphytoptus amoni* | 21111111?1 | 2110341011 | 0101101111 | 0112–01001 | 1110000422 | 0001121001 | 3122200411 | 71661100–1 | 1111111111 | 1100510000 | 0231a00111 | 1121??5 |
| *Tegoprionus bicristatus* | 2111111101 | 2110331241 | 0101101111 | 0101001001 | 1110000522 | 0001121001 | 2122100411 | 61604140–1 | 1111111111 | 1123310000 | 0231900111 | 1123115 |
| *Monotrymacus quadrangulari* | 2111111101 | 2110331051 | 0101101111 | 2101101101 | 1110000422 | 0001121001 | 3122100311 | 71821140–1 | 1111111111 | 1100310000 | 0241900111 | 1121115 |
| *Nacerimina gutierrezi* | 2111111101 | 2110341201 | 0101101111 | 2112–01201 | 1110000322 | 0101121001 | 810--00411 | 11100110–1 | 1111111111 | 1123310000 | 0111600111 | 1121115 |
| *Nalepella tsugifoliae* | 21111111?1 | 1110011011 | 0101101111 | 0101201101 | 1110000212 | 0001121001 | 9112200411 | 51300110–1 | 1111111111 | 1120310000 | 0651400111 | 1121121 |
| *Neoacaphyllisa lithocarpi* | 21111111?1 | 2110341021 | 0101101111 | 2101101001 | 1110002422 | 0001121001 | 2122200411 | 71601100–1 | 1111111111 | 1100510000 | 0215800111 | 1121??6 |
| *Neoacarhis aglaiae* | 21111111?1 | 2110441011 | 1201101111 | 2101001001 | 111101--22 | 1101121012 | 610--00411 | 71601100–1 | 1111111111 | 1100310000 | 0215700111 | 1121??1 |
| *Neocatarhinus bambusae* | 21111111?1 | 2110451021 | 0101101111 | 2101001001 | 1111000222 | 0101121012 | 6122200411 | 61601100–1 | 1111111111 | 1123310000 | 0241 [56] 00111 | 1121??3 |
| *Neocecidophyes mallotivagrans* | 2111111101 | 2110341231 | 0101101111 | 2101301001 | 1110000322 | 0001121001 | 2122100111 | 11431100–1 | 1111111111 | 1100110000 | 0221800111 | 1132111 |
| *Neocolopodacus mitragynae* | 2111111101 | 2110331051 | 0101101111 | 0101101001 | 111001--24 | 0001121001 | 2122100411 | 51620100–1 | 1111111111 | 1123510000 | 0211900111 | 1121115 |
| *Neocosella ichnocarpae* | 2111111101 | 2110341031 | 0101101111 | 2112–01001 | 111001--24 | 0001121001 | 2122200411 | 61500100–1 | 1111111111 | 1123510000 | 2--1902111 | 113???6 |
| *Neocupacarus flabelliferis* | 2111111131 | 2110341221 | 0111111111 | 2101001–11 | 1111000422 | 1001121001 | 2122100411 | 71501100–1 | 1111111111 | 1123310000 | 0211800111 | 1121114 |
| *Neodialox palmyrae* | 2111111101 | 2111--2--1 | 0101101111 | 0101001001 | 1111001422 | 0001121012 | 210--00411 | 5161110111 | 1111111111 | 1123310000 | 0765300111 | 1121111 |
| *Neodichopelmus samoanus* | 2111111101 | 2110341241 | 0101101111 | 2101201001 | 111001--22 | 0001121001 | 2122300411 | 71620110–1 | 1111111111 | 1110310000 | 0235a00111 | 1121??5 |
| *Neodicrothrix tiliacorae* | 2111111121 | 2110341131 | 0111111111 | 2101101001 | 111001--22 | 0101121001 | 8122300411 | a1420100–1 | 1111111111 | 1100310000 | 0222900111 | 1121115 |
| *Neodiptilomiopus vishakantai* | 2111111101 | 2111–11–1 | 1201101111 | 1112–13–01 | 111101--22 | 1101121012 | 110--00411 | 51501110–1 | 1111111111 | 1123310000 | 0215820111 | 1121113 |
| *Neolambella ligustri* | 21111111?1 | 2111--2--1 | ??011???11 | 0112–01001 | 111111--22 | 1101121012 | 111--00411 | 51501100–1 | 1111111111 | 1100310000 | 0??5800111 | 1121??1 |
| *Neomesalox kallarensis* | 2111111101 | 2110331241 | 0111101111 | 2112–01001 | 1110000422 | 0001121001 | 2122800411 | 6140116111 | 1111111111 | 1100310000 | 0231900111 | 1121??1 |
| *Neometaculus bauhiniae* | 2111111101 | 2110341001 | 0101101111 | 2112–01001 | 1110000422 | 0001121001 | 2122100411 | 71621100–1 | 1111111111 | 1100510000 | 0231700111 | 1121115 |
| *Neophantacrus mallotus* | 2111111101 | 2110331241 | 0101101111 | 2101301001 | 1110000422 | 0001121001 | 210--00311 | 61604110–1 | 1111111111 | 1100510000 | 0231800111 | 1121?16 |
| *Neophytoptus ocimae* | 2111111111 | 2110331221 | 0101101111 | 0101001101 | 1111000422 | 1001121001 | 2122100411 | 11500110–1 | 1111111111 | 1123310000 | 0221900111 | 1121115 |
| *Neopropilus jatrophus* | 21111111?1 | 2011--2--0 | 0111111111 | 2101101101 | 111001--12 | 0001121001 | 8122100411 | b1620200–1 | 1111111111 | 11??310000 | 0221900111 | 1121??1 |
| *Neorhynacus rajendrani* | 2111111101 | 21104410 [12] 1 | 1201101111 | 1101101001 | 1111000022 | 1101121012 | 110--00411 | 61501110–1 | 1111111111 | 1122210000 | 0245800111 | 1121113 |
| *Neotegonotus fastigatus* | 2111111101 | 2110331251 | 0101101111 | 0101101001 | 1110000522 | 0001121001 | 2122400311 | 61621160–1 | 1111111111 | 1100310000 | 0231900111 | 1121115 |
| *Neserella decora* | 2111111101 | 2111--2--1 | 0101111111 | 0112–01001 | 111001--22 | 0001121001 | 210--00411 | 51100110–1 | 1111111111 | 1123510000 | 0211900111 | 1133213 |
| *Norma lanyuensis* | 21111111?1 | 2111--2--1 | 1201101111 | 2112–01001 | 111001--22 | 1101121012 | 110--00411 | 51500100–1 | 1111111111 | 1100510000 | 0215700111 | 1121??5 |
| *Notacaphylla chinensiae* | 2111111101 | 2110331041 | 0101101111 | 2112–01001 | 111001--22 | 0001121001 | 2122800411 | 7162110121 | 1111111111 | 1100310000 | 0105800111 | 1121116 |
| *Notaceria tetrandiae* | 2111111101 | 2110331241 | 0101101111 | 0101401001 | 111001--21 | 0011121001 | 210--00111 | 11100110–1 | 1111111111 | 1100310000 | 0221800111 | 1121116 |
| *Notallus nerii* | 2111111101 | 2110331241 | 0101101111 | 0101101101 | 1110000422 | 0001121001 | 6122800311 | 71811150–1 | 1111111111 | 1100310000 | 0221900111 | 1121115 |
| *Nothacus tuberculatus* | 2111111141 | 2110331041 | 0101101111 | 2101401001 | 111101--22 | 0001121001 | 2122100411 | a1100110–1 | 1111111111 | 1121210000 | 0211800111 | 1121115 |
| *Nothopoda rapaneae* | 2111111101 | 2110331241 | 0101101111 | 2112–01001 | 111001--22 | 0001121001 | 610--00411 | 11100110–1 | 1111111111 | 1123210000 | 2--1902111 | 1121115 |
| *Notostrix attenuata* | 2111111101 | 2110331041 | 0101101111 | 2101201001 | 1110000322 | 0101121001 | b122400311 | 91611100–1 | 1111111111 | 1123310000 | 0211600111 | 1121115 |

| 318-taxon data matrix | | | | | | | | | | | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456 |
| *Novophytoptus rostratae* | 2111111101 | 2010111241 | 0101101111 | 0101101401 | 1111000422 | 1001121001 | b10--00411 | 21300110-1 | 1111111111 | 1123310000 | 0241 [ab] 00111 | 1112211 |
| *Novophytoptus stipae* | 2111111141 | 2010001241 | 0101101111 | 0101001401 | 1111000522 | 1001121001 | 220--00411 | 41100110-1 | 1111111111 | 1123310000 | 0242900111 | 1112211 |
| *Oziella yuccae* | 2111111101 | 2010341050 | 0101101111 | 0101001301 | 1110000412 | 0001121001 | 610--00411 | 11100110-1 | 1111111111 | 1120310100 | 0221 [56] 10111 | 1121211 |
| *Palmiphytoptus oculatus* | 2111111101 | 2011--2--1 | 0101101111 | 1101101101 | 111001--22 | 0001121001 | d221200211 | 11101110-1 | 1111111111 | 1100110000 | 0211500111 | 1123111 |
| *Pangacarus grisalis* | 2111111101 | 2110331031 | 0101101111 | 2112-01001 | 111101--22 | 0001121001 | 2122200411 | 51600100-1 | 1111111111 | 1120510000 | 2--1802111 | 1121116 |
| *Paracalacarus podocarpi* | 2111111101 | 2111--2--1 | 0101101111 | 1101101101 | 1111000122 | 1101121001 | 6112100411 | 51511110-1 | 1111111111 | 1123310000 | 0231900111 | 1121115 |
| *Paracaphylla streblae* | 2111111101 | 2110451011 | 0101101111 | 1101301001 | 1111000422 | 1001121001 | 210--00411 | 7162111141 | 1111111111 | 1100210000 | 0235 [56] 00111 | 1121113 |
| *Paraciota tetracanthae* | 2111111101 | 2110341241 | 0101101111 | 2101001001 | 111101--22 | 1101121001 | 2122100111 | 71620100-1 | 1111111111 | 1100310000 | 0231800111 | 1121116 |
| *Paracolomerus casimiroae* | 2111111101 | 2110321241 | 0101101111 | 0101401001 | 1110000422 | 0001121001 | 210--00411 | 11100110-1 | 1111111111 | 1120310000 | 0211800111 | 1122111 |
| *Paraphytoptella arnaudi* | 21111111?1 | 2110221241 | 0101111111 | 0101301001 | 1110000422 | 0001121001 | 210--00411 | 11800110-1 | 1111111111 | 1123310000 | 0211800111 | 1121113 |
| *Pararhynacus photiniae* | 21111111?1 | 2111-12-1 | 0101101111 | 2101001101 | 1111000122 | 1001121012 | 610--00411 | a1501100-1 | 1111111111 | 1120310000 | 0?45900111 | 1121??5 |
| *Pareria fremontiae* | 21111111?1 | 2110331201 | 0101101111 | 0101101001 | 1110000422 | 0001121001 | 210--00411 | 11800110-1 | 1111111111 | 1123310000 | 0221800111 | 1121115 |
| *Pentamerus rhamnicroceae* | 2111111101 | 2110331241 | 0101101111 | 0101001101 | 1110000422 | 0001121001 | 2122400411 | 6160114121 | 1111111111 | 1123310000 | 0231800111 | 1121116 |
| *Pentaporca taiwanensis* | 21111111?1 | 1110131001 | 0101101111 | 0101301101 | 1110000022 | 0001121001 | 7122100411 | 51611100-1 | 1111111111 | 1100210000 | 0651600111 | 1121??1 |
| *Pentasetacus araucaria* | 2111111101 | 1010331000 | 0101101111 | 0101201201 | 1110000412 | 0001121001 | 9122200311 | 31100110-1 | 1111111111 | 1100310000 | 0225a00111 | 1121?21 |
| *Peralox insolita* | 2111111101 | 2110231201 | 0101101111 | 0101201001 | 1110000422 | 0001121012 | 2122900411 | 616461e0-1 | 1111111111 | 1100310000 | 0331600111 | 1121111 |
| *Phantacrus lobatus* | 2111111101 | 1110011201 | 0101101111 | 0101101101 | 1110000212 | 0001121001 | 2122800411 | 61654100-1 | 1111111111 | 1123310000 | 0551600111 | 1121121 |
| *Phyllocoptes calisorbi* | 2111111101 | 2110331021 | 0101101111 | 1101001101 | 1110000222 | 0001121001 | 2122800411 | 61100110-1 | 1111111111 | 1121310000 | 0211900111 | 1121115 |
| *Phyllocoptruta arga* | 2111111141 | 2110331251 | 0101101111 | 2101401001 | 1110000222 | 0001121001 | 3122800411 | 71601160-1 | 1111111111 | 1111210000 | 0211a00111 | 1121115 |
| *Phyllocoptruta oleivora* | 2111111101 | 2110331021 | 0101101111 | 1101101101 | 1110000422 | 0001121001 | 6122100411 | 71611100-1 | 1111111111 | 1123310000 | 0211800111 | 1121115 |
| *Phytoptus avellanae* | 2111111101 | 2010331010 | 0101101111 | 0101001101 | 1110000522 | 0001121001 | 210--00411 | 11100110-1 | 1111111111 | 1113310000 | 0211 [89] 00111 | 1123213 |
| *Platyphytoptus sabinianae* | 2111111101 | 2110331021 | 0101101111 | 0101201001 | 1110000422 | 0001121001 | e121600311 | 81161110-1 | 1111111111 | 1123210000 | 0211800111 | 1121113 |
| *Porcupinotus humpae* | 2111111101 | 2110331241 | 0101101111 | 0101001001 | 1110000422 | 0001121001 | 2122200111 | 6160116111 | 1111111111 | 1111310000 | 0231500111 | 1121116 |
| *Porosus monosporae* | 2111111121 | 2110331241 | 0101101111 | 2101101001 | 1110000022 | 0001121001 | 2122100411 | 614001c0-1 | 1111111111 | 1100310000 | 0231900111 | 1121111 |
| *Proartacris pinivagrans* | 2111111101 | 2110341221 | 0101101111 | 0101001001 | 1110000222 | 0001121001 | 2122200411 | 61600110-1 | 1111111111 | 1123310000 | 0231900111 | 1121114 |
| *Prodiptilomiopus auriculatae* | 2111111141 | 2111--2--1 | 1101101111 | 2101201001 | 111111--22 | 1101121012 | 410--00411 | 51601100-1 | 1111111111 | 1100310000 | 0235600111 | 1121116 |
| *Proneotegonotus antiquorae* | 2111111101 | 2110451051 | 0111111111 | 2101101001 | 111001--22 | 0101121001 | 2122100411 | a1620100-1 | 1111111111 | 1100310000 | 0231800111 | 1121115 |
| *Prophyllocoptes riveae* | 2111111101 | 2110451051 | 0101111111 | 2101101001 | 1110000322 | 0001121001 | 2122200411 | 71620160-1 | 1111111111 | 1100310000 | 0221600111 | 1121111 |
| *Propilus gentyi* | 2111111101 | 2011--2--1 | 0101101111 | 2101101301 | 111001--22 | 0001121001 | 6122100411 | 71630200-1 | 1111111111 | 1120310000 | 0201a00111 | 1121121 |
| *Prothrix aboula* | 2111111101 | 0011--2--0 | 0111101111 | 2101301101 | 111001--12 | 0001121001 | 8122100111 | 71601200-1 | 1111111111 | 1100210000 | 0241800111 | 113??11 |
| *Pyelotus africanae* | 2111111101 | 2110331241 | 0101101111 | 1101201101 | 1110000622 | 0001121001 | 2122200411 | 71801150-1 | 1111111111 | 1123310000 | 0231900111 | 1121??5 |
| *Quadracus urticarius* | 2111111101 | 2110331201 | 0101101111 | 2101001001 | 1110000422 | 0001121012 | 2112600411 | 91631100-1 | 1111111111 | 1123310000 | 0211800111 | 1123116 |
| *(Kropczynella) mangiferae* | 2111111101 | 2110341021 | 0101101111 | 0101101101 | 1110000322 | 0001121012 | 210--00411 | 51601110-1 | 1111111111 | 1123310000 | 0231800111 | 1121??3 |
| *Quadriporca mangiferae* | 21111111?1 | 2110341011 | 0101101111 | 2101001001 | 1111000222 | 1001121012 | 2122200411 | a1601100-1 | 1111111111 | 1100310000 | 0231800111 | 1121??4 |
| *Quintalitus squamosus* | 2111111141 | 2110331241 | 0101101111 | 1101401001 | 111101--22 | 0001121001 | 2122800411 | 71601100-1 | 1111111111 | 1123510010 | 0211800111 | 1121??6 |
| *Ramaculus mahoe* | 2111111101 | 2110321241 | 0101111111 | 0112-01001 | 111001--22 | 0001121001 | 210--00411 | 61100190-1 | 1111111111 | 1123510000 | 0111 [89] 00111 | 1121114 |
| *Rectalox falita* | 2111111101 | 2110331241 | 0101101111 | 2101101001 | 1110000322 | 0001121001 | 2122600111 | 61601100-1 | 1111111111 | 1123310000 | 0221800111 | 1121115 |
| *Retracrus johnstoni* | 2111111101 | 2010341041 | 0111101111 | 2101001201 | 1110100212 | 0101121001 | 8122100111 | a163120121 | 1111111111 | 1100210000 | 0241700111 | 1121111 |
| *Rhinophytoptus concinnus* | 21111111?1 | 2110331201 | 0101101111 | 2101?01?01 | 1110000422 | 0001121012 | ?112100411 | 61100110-1 | 1111111111 | 11??310000 | 0331700111 | 112???1 |
| *Rhinotergum schestovici* | 2111111101 | 2110331011 | 0101101111 | 0101301001 | 1110000422 | 0001121012 | 2122200411 | 615201f0-1 | 1111111111 | 1100310000 | 0531900111 | 1121111 |
| *Rhombacus morrisi* | 2111111101 | 2110341011 | 0101101111 | 2101001101 | 1110000022 | 0001121001 | 3122300411 | a1620110-1 | 1111111111 | 1123510000 | 0341800111 | 1121115 |

| 318-taxon data matrix | | | | | | | | | | | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| | 0123456789 | 0123456789 | 0123456789 | 01234**5**6789 | 0123456789 | 0123456**789** | 0123456789 | 01234**5**6789 | 0123456789 | 012345678**9** | 0123456789 | 0123456 |
| *Rhynacus arctostaphyli* | 21111111?1 | 2111—12–1 | 1201101111 | 1112–**0**1001 | 1111000422 | 1101121**012** | 110––00411 | 61501**1**10–1 | 1111111111 | 110041000**0** | 0215600111 | 1121115 |
| *Rhyncaphytoptus ficifoliae* | 21111111?1 | 2110331201 | 0101101111 | 01012**0**1101 | 1110000422 | 0001121**012** | 2122600411 | 61710**1**12–1 | 1111111111 | 110031000**0** | 0221700111 | 1121111 |
| *Sakthirhynchus canariae* | 21111111?1 | 2111––2––1 | 1201101111 | 0112–**0**1001 | 111111––22 | 1101121**012** | 110––00411 | 51601**1**00–1 | 1111111111 | 110031000**0** | 0211700111 | 1121??1 |
| *Schizacea gynerii* | 2111111101 | 2111––2––1 | 0111111111 | 21010**0**1101 | 1111000322 | 1101121**001** | 2122200411 | 71621**1**00–1 | 1111111111 | 112331000**0** | 0205800111 | 1121113 |
| *Schizoempodium mesophyllincola* | 2111111101 | 2110341211 | 0101101111 | 01010**0**1001 | 1110000522 | 0001121**001** | b121800411 | 31100**1**10–1 | 1111111111 | 112331000**0** | 0235900111 | 1122115 |
| *Scoletoptus duvernoia* | 2111111101 | 2110331–41 | 0101101111 | 0112–**0**1001 | 1110000122 | 0001121**001** | a10––00[14]11 | 41400**1**[1a]0–1 | 1111111111 | 110031000**0** | 0111900111 | 1121116 |
| *Setoptus jonesi* | 2111111101 | 1110221101 | 0101101111 | 01011**0**1101 | 1110000312 | 0001121**001** | 510––00311 | 81101**1**10–1 | 1111111111 | 112331000**0** | 0231300111 | 1121121 |
| *Shevtchenkella juglandis* | 21111111?1 | 2110341241 | 0101101111 | 01011**0**1001 | 1110000422 | 0001121**001** | 3122220311 | 71631**1**00–1 | 1111111111 | 112331000**0** | 0211900111 | 1121115 |
| *Sierraphytoptus alnivagrans* | 2111111101 | 2010331010 | 0101101111 | 01012**0**1101 | 1110000422 | 0001121**001** | 2122110311 | 71610**1**00–1 | 1111111111 | 110031000**0** | 0231b00111 | 1121211 |
| *Sinacus erythrophlei* | 21111111?1 | 2110331241 | 0101101111 | 01011**0**1001 | 111001––22 | 0001121**001** | 2122100411 | 71601**1**00–1 | 1111111111 | 110031000**0** | 0221800111 | 1121??6 |
| *Stenacis palomaris* | 2111111101 | 2110331201 | 0101101111 | 11013**0**1001 | 1110000522 | 0001121**001** | 2121[689]00411 | 31100**1**10–1 | 1111111111 | 112331000**0** | 0222a00111 | 1121116 |
| *Stenarhynchus aristidus* | 2111111101 | 2110331231 | 0101101111 | 11011**0**1101 | 1110000322 | 0001121**012** | 2122800411 | 31100**1**10–1 | 1111111111 | 112331000**0** | 0221300111 | 1111116 |
| *Steopa bauhiniae* | 2111111101 | 2111—12–1 | 1011101111 | 1112–**0**1001 | 111101––22 | 1101121**012** | 110––00411 | 51501**1**00–1 | 1111111111 | 111031000**0** | 0217000111 | 1121??5 |
| *Suthamus chiangmi* | 2111111141 | 2110451111 | 1001101111 | 1112–**0**1001 | 1111100222 | 1101121**012** | 110––00411 | 51601**1**00–1 | 1111111111 | 111021000**0** | 0215520111 | 1121??6 |
| *Tegolophus califraxini* | 2111111101 | 2110331041 | 0101101111 | 21011**0**1001 | 1110000622 | 0001121**001** | 2122200411 | 51611**1**[01]0–1 | 1111111111 | 110031000**0** | 0231700111 | 1121116 |
| *Tegonotus mangiferae* | 2111111101 | 2110451221 | 0101101111 | 01011**0**1101 | 1110000122 | 0001121**001** | 3122300411 | 71631**1**00–1 | 1111111111 | 112331000**0** | 0231700111 | 1121115 |
| *Tegoprionus dentatus* | 2111111101 | 2110331041 | 0101101111 | 21011**0**1001 | 1110000422 | 0001121**001** | 3122200311 | 71611**1**00–1 | 1111111111 | 112031000**0** | 0231900111 | 1121??6 |
| *Tergilatus sparsus* | 2111111101 | 2110341221 | 0101111111 | 01010**0**1101 | 1110000422 | 0001121**001** | 2122100411 | 81621**1**10–1 | 1111111111 | 112351000**0** | 0251b00111 | 1121115 |
| *Tetra concava* | 2111111101 | 2110111241 | 0101101111 | 01011**0**1001 | 1110000422 | 0001121**001** | 2122800411 | 71611**1**20–1 | 1111111111 | 111031000**0** | 0211900111 | 1121116 |
| *Tetraspinus lentus* | 21111111?1 | 2110341241 | 0101101111 | 01011**0**1101 | 1110000422 | 0001121**001** | 1122120411 | 71601**1**00–1 | 1111111111 | 110031000**0** | 0231900111 | 1121115 |
| *Thailandus diospyrosae* | 2111111141 | 2110451241 | 1201111111 | 11011**0**1001 | 111111––22 | 0101121**012** | 110––00411 | 51811**1**00–1 | 1111111111 | 110051000**0** | 0211700111 | 1121??6 |
| *Thamnacus rhamnicola* | 21111111?1 | 2110331041 | 0101101111 | 21011**0**1101 | 1110000522 | 0001121**001** | 2122100311 | 71611**1**00–1 | 1111111111 | 110031000**0** | 0231900111 | 1121??6 |
| *Trimeracarus heptapleuri* | 21111111?1 | 2110331001 | 0101101111 | 1101?**0**1?01 | 1110000522 | 0001121**001** | 210––00311 | 71501**1**10–1 | 1111111111 | 11??31000**0** | 0231800111 | 112???6 |
| *Trimeroptes eleyrodiformis* | 2111111101 | 2110331011 | 0101101111 | 11011**0**1001 | 1111000222 | 1001121**012** | 2122700111 | 71501**1**0111 | 1111111111 | 112331000**0** | 0335800111 | 1121113 |
| *Trisetacus ehmanni* | 2111111101 | 1110221100 | 0101101111 | 01011**0**1201 | 1110000312 | 0001121**001** | 610––00411 | 11100**1**10–1 | 1111111111 | 111111000**0** | 0211600111 | 1121121 |
| *Trisetacus pini* | 2111111101 | 1110221100 | 0101101111 | 01011**0**1101 | 1110000312 | 0001121**001** | 610––00411 | 11100**1**10–1 | 1111111111 | 111121000**0** | 0211600111 | 1121121 |
| *Tumescoptes trachycarpi* | 2111111101 | 2110341221 | 0111111111 | 01010**0**1101 | 1111000322 | 1101121**001** | 2122200411 | 81211**1**00–1 | 1111111111 | 111121000**0** | 0211b00111 | 1121115 |
| *Ursynovia ulmi* | 2111111101 | 2110001241 | 0101101111 | 01011**0**1001 | 1110000422 | 0001121**001** | 210––00411 | 71601**1**00–1 | 1111111111 | 110031000**0** | 0231800111 | 1121??3 |
| *Vasates quadripedes* | 21111111?1 | 2110––1051 | 0101101111 | 21010**0**1001 | 1110000422 | 0001121**001** | 2122800411 | 61610**1**10–1 | 1111111111 | 112331000**0** | 0115700111 | 1121115 |
| *Vimola syzygii* | 2111111101 | 2111—10–1 | 1201101111 | 2112–**0**1101 | 111101––22 | 1101121**012** | 110––00411 | 51601**1**10–1 | 1111111111 | 112321000**0** | 0215800111 | 1121??3 |
| *Vittacus mansoni* | 2111111101 | 2110331241 | 0101101111 | 21012**0**1001 | 1110000622 | 0001121**001** | 2122800311 | 61611**1**40–1 | 1111111111 | 112331000**0** | 0231900111 | 1121115 |

# APPENDIX E.

List of morphological characters and character states in 66 taxon data set used in analyses. All characters were analyzed unordered, except characters 4, 5, 49, and 52 which were ordered. Except for the ordered characters, no transformation series are implied by the character state numbers. The characters and character states are sub-samples of the characters used in the analyses of the 318 taxon data set, and see Chapter 4 for a complete discussion, and source, of the characters. Some of the character states not applicable for the taxon sample for the 66 taxon data set were omitted, but the characters could not be renumbered in time, and those in between state applicable, were left in. These didn’t have an influence on the analyses, and the states will be renumbered, and those inapplicable will be excluded in the data sets for publication in peer reviewed journals.

# CHAETOTAXY

## Gnathosomal setae

**0.** Gnathosomal palpal setae *d*
0 = present, simple
1 = present, forked
2 = absent

## Prodorsal setae

**1.** Setae *vi*
0 = pair present
1 = one seta absent, position of remaining seta shifted to mid-anterior
2 = absent

**2.** Setae *ve*
0 = present
1 = absent

**3.** Setae *sc* (presume setae *sc* in the Eriophyoidea are setae *sci* (*sc*1))
0 = present
1 = absent

**4.** Setae *sc* relative length
0 = exceptionally long (> 100)
1 = very long (66 – 100)
2 = long (31 – 65)
3 = average (4 – 30)
4 = short (1 – 3)
5 = minute (not measurable, less than 1 long)

**5.** Setae *sc* length relative to prodorsal shield
0 = exceptionally long (> three shield length)
1 = very long (< three, but > or equal to 1.5 shield length)
2 = long (< 1.5, but > or equal to one shield length)
3 = average length (< one, but > 0.2 shield length)
4 = short (< or equal to 0.2, but > 0.07 shield length)
5 = very short (< or equal to 0.07 shield length)

**6.** Scapular setal tubercles (dorsal tubercles)
0 = primary absent
1 = present
2 = secondary absent

**7.** Setae *sc*, and/or *sc* setal tubercles position
0 = ahead of rear shield margin (ahead, but less than half of shield ahead)
1 = well ahead of rear shield margin (on half of shield or further anteriad)
2 = on rear shield margin, or slightly ahead of rear shield margin

**8.** Direction of projection of setae *sc*
0 = anteriad, diverging
1 = anteriad: parallel, converging or up
2 = medially
3 = up and to the outside
4 = posteriad, usually diverging
5 = posteriad, converging
6 = any direction

## Opisthosomal setae

**9.** Setae *c1* (subdorsal setae)
0 = present
1 = absent

**10.** Setae *c2* (lateral setae)
0 = present
1 = absent

**11.** Setal tubercles of setae *c2* (lateral setae)
0 = primary absent
1 = present
2 = secondary absent

**12.** Setae *d* (1st ventral setae)
0 = present
1 = absent

**13.** Setae *e* (2nd ventral setae)
0 = present
1 = absent

**14.** Setae *h1* (accessory setae)
0 = present
1 = minute or dot-like (2 µ or less)
2 = absent

## Coxal plates setae

**15.** Setae *1b*
0 = present
1 = absent

**16.** Setal tubercles of setae *1b*
0 = primary absent
1 = present
2 = secondary absent

**17.** Distance between setal tubercles of setae *1b* in comparison with distance between setal tubercles of setae *1a*
0 = *1b* clearly further apart than *1a*
1 = *1b* slightly further apart than *1a*
2 = *1b* longitudinally in line with *1a*
3 = *1b* slightly closer together than *1a*
4 = *1b* clearly closer together than *1a*

**18.** Setae *1a*
0 = ahead of setae *2a*
1 = slightly ahead of setae *2a*
2 = in line with setae *2a*
3 = slightly behind setae *2a*
4 = behind setae *2a*

## Leg setae

**19.** Leg I: basiventral femoral setae (*bv*)
0 = present
1 = absent

**20.** Leg I: setae *l*’’ (antaxial genual setae)

0 = present
1 = absent

**21.** Leg I: setae *l'* (paraxial tibial setae)
0 = present
1 = absent

**22.** Leg I: setae *l'* (paraxial tibial setae) position
0 = dorsal on tibia
1 = displaced to inner side of tibia
2 = absent

**23.** Leg I: setae *l'* (paraxial tibial setae) vertical position
0 = close to apical (distal) margin (less than quarter tibial length from distal margin)
1 = at about distal quarter
2 = at distal third
3 = on about half of tibia
4 = at basal third
5 = at basal quarter
6 = near basal margin (less than a quarter from basal margin)

**24.** Leg I: tibial solenidion *φ*
0 = present, in "normal" position
1 = present, in ventrodistal position
2 = absent

**25.** Leg I: tarsal solenidion *ω* position
0 = antaxial, on distal third of tarsus
1 = dorsal, about mid-tarsus
2 = dorsal, close to and above empodium
3 = lateral, close to empodium, on outer side of tarsus
4 = lateral, close to empodium, on inner side of tarsus
5 = ventrad of empodium

**26.** Leg II: setae *bv* (basiventral femoral setae)
0 = present
1 = absent

**27.** Leg II: setae *l''* (antaxial genual setae)
0 = present
1 = absent

**28.** Leg II: paraxial, fastigial, tarsal setae (*ft'*)
0 = present
1 = absent

## GNATHOSOMA

**29.** Gnathosoma: oral stylet
0 = of short form (Fig. 3.22a)
1 = of long form (Fig. 3.22b)

**30.** Gnathosoma: chelicerae
0 = very long and recurved in stylophore
1 = relatively straight and relatively short in comparison with palpi (Fig. 3.22a)
2 = abruptly bent down near base and relatively long in comparison with palpi (Fig. 3.22b)

## PRODORSUM

### Prodorsal shield

**31.** Prodorsal shield shape
0 = almost absent
1 = broadly oval (shorter than wide)
2 = triangular or subtriangular, sometimes with rounded sides or more semicircular
3 = subtriangular with bulging sides
4. = subtriangular and broad
5 = inverted subtriangular
6 = circular or subcircular
7 = diamond-shaped
8 = subquadrate
9 = sub-rectangular
A = elongate oval
B = elongate triangular

**32.** Prodorsal shield frontal lobe
0 = absent
1 = short or indistinct (not reaching across cheliceral bases)
2 = present

**33.** Prodorsal shield frontal lobe
0 = absent
1 = present, thin and flexible
2 = present, rigid

**34.** Apical edge of frontal lobe
0 = lobe absent
1 = blunt and rounded
2 = blunt and rounded, but narrow in shape (e.g. when lobe is more triangular)
3 = blunt and rounded with irregular edge
4 = sharply pointed
5 = spine-like
6 = square with rounded corners
7 = rectangular anterior lobe with indentation
8 = acuminate, but not sharply pointed
9 = small indentation
A = broad, clear indentation with broad lobes
B = fine, slender lateral extensions

### Prodorsal shield ornamentation

**35.** Prodorsal shield ornamentation (Eriophyoidea)
0 = shield absent
1 = ornamentation absent
2 = absent centrally, ornamented along edges
3 = faint, obscure or virtually unornamented
4 = ornamentation present

## IDIOSOMA

### Opisthosoma shape and microtuberculation

**36.** Body shape
0 = varying from rounded to oval
1 = vermiform (similar to *Phytoptus* and *Aceria* spp.)
2 = cylindrical
3 = vermiform, elongated
4 = vermiform, extremely elongated

5 = fusiform, medium thick to more “fat” (similar to *Diptilomiopus* spp.), with or without narrow rear end
6 = fusiform, elongated, medium thick (similar to *Aculus* or *Abacarus* spp.)
7 = fusiform, flattened
8 = fusiform, extremely flattened
9 = fusiform, very long
A = fusiform, broad anteriorly, very narrow tail
B = fusiform, flattened, narrow tail (e.g. *Aberoptus samoae*)

**37.** Opisthosoma dorsoventral differentation: annuli
0 = annuli absent
1 = subequal and similar in appearance, dorsally and ventrally
2 = subequeal, differentiated in appearance dorsally and ventrally
3 = subequal, numerous, and visibly narrower than “normal”
4 = subequal or equal in count, but broader than “normal”
5 = differentiated into slightly broader dorsal annuli and narrower ventral annuli
6 = clearly differentiated into broader dorsal annuli and narrower ventral annuli
7 = dorsal annuli extremely broader than ventral annuli
8 = variably different

**38.** Opisthosomal dorsal annuli
0 = without lateral extensions or lobes
1 = very slight lateral projection (no demarcation line laterally)
2 = with slight lateral projection (in lateral view, dorsal annuli separated from ventral annuli by some sort of demarcation); the extend of lateral projection not always clear, some of these species not assigned to Tegonotini
3 = with clear lateral extensions or lobes (currently defining state for Tegonotini)
4 = small spine-like lobes on margin between dorsal and ventral annuli
5 = extensive lateral lobes, also present dorsally
6 = ventro-lateral ridges forming grooves
7 = lateral lobes uneven, extending more from some annuli

**39.** Opisthosoma: ridge(s) and/or furrow(s)
0 = absent
1 = present
2 = absent, except for some rear dorsal annuli which are higher than the others
3 = some anterior dorsal annuli fused into ellaborate dorsal structures
4 = with large lobes dorsally

**40.** Dorsal annuli of telosome
0 = annuli absent
1 = not fused
2 = fused

**41.** Dorsal annuli
0 = without microtubercles (mostly smooth)
1 = entirely microtuberculated
2 = entire but mostly obscure or faint
3 = smooth with few scattered microtubercles in sparse clumps (laterally and/or middorsally) (e.g. *Chiangmaia longifolii*) or with clumps or spots with microtubercles (see *Duabangus chiangmai*)
4 = smooth with microtubercles on ridges: lateral (see *D. stephanus*); relatively large spines on ridges (see *Pentamerus rhamnicroceae*)
5 = faint but clear on lateral ridges (see *Notallus nerii*)
6 = with central area smooth, and microtuberculated laterally

## Secretions

**42.** Wax secretion
0 = absent
1 = present in adults

2 = only present in immatures

**43.** Wax type and secreting structures
0 = absent
1 = present, thickened wax bearing ridges
2 = present, wax from tubercles
3 = broad wax rim around shield, large wax plates along body margin
4 = body covered with wax

## LEGS, COXAL PLATES AND STERNAL AREA

### Ornamentation on coxal plates andmorphology of sternal area

**44.** Coxal plates I
0 = unornamented (mostly smooth) (also including described as "virtually unornamented")
1 = faintly or slightly ornamented
2 = ornamented
3 = continuation of body striae

**45.** Coxal plates II
0 = unornamented (smooth), including virtually unornamented
1 = faintly ornamented
2 = sparsely ornamented
3 = ornamented
4 = continuation of body striae

**46.** Prosternal apodeme: coxae I
0 = more widely separated than found in the Eriophyoidea, prosternal apodeme not present, "normal' ventral area extended between coxae
1 = widely separated (see *Davisella breitlowi*, *Neocecidophyes mallotivagrans*, *Palmiphytoptus oculatus* and *Trisetacus ehmanni*)
2 = separated
3 = coxae I touching, usually with sternal apodeme present
4 = sternal apodeme visibly broader than usually in the Eriophyoidea (see *Rhynacus arctostaphyli*)
5 = totally fused centrally (or prosternal apodeme may be present but effaced – not "visible" as sternal line)

## LEGS (excluding coxae)

**47.** Leg I: femur and genu articulation
0 = normally articulated
1 = division weak, almost fused
2 = not articulated, totally fused
3 = genu present, but "fused" to femur

**48.** Leg I: tibia presence
0 = present
1 = partly fused to tarsus
2 = completely fused to tarsus (absent)

**49.** Leg I: tibia length
*1 = short (2-3 micron)
2 = average (4-11 micron)
3 = medium long (12-13 micron)
4 = average long (14-15 micron)
5 = long (16-17 micron)
6 = very long (19-20 micron)
7 = very, very long (22 micron)

8 = exceptionally long (30 micron)
* character state numbers start at 1, and not at 0, because 0 (absent) was replaced with "-" (not applicable) in the final matrix that was analysed (Appendix E)

**<u>50.</u>** Leg I: length of tibia in relation to length of tarsus
0 = tibia shorter than half of tarsus length
1 = tibia shorter than tarsus, half or more of tarsus length
2 = tibia length equal to tarsus length
3 = tibia longer than tarsus, but less than half the length of tarsus longer
4 = tibia longer than tarsus, half or more, but less than twice the tarsus length
5 = tibia about twice as long as tarsus

**<u>51.</u>** Leg I: empodium
0 = pad-like with numerous rays
1 = simple
2 = simple, distally elongated
3 = simple, rays unsymmetrical (more rays on one side than the other) e.g. *Dechela epelis*
4 = partly divided
5 = divided
6 = divided, stems unequal
7 = divided, stems pad-like with numerous rays
8 = divided, with central stem
9 = palmate
A = basal rays finely branched, hair-like (e.g. *Brevulacus reticulatus*)
B = reduced to a bristle
C = six tenent hairs basally and centrally attached

**<u>52.</u>** Leg I: number of empodial rays.
0 = numerous rays (can not count)
1 = 16-rayed or more
2 = 11-12 rayed
3 = 10-rayed
4 = 9-rayed
5 = 8-rayed
6 = 7-rayed
7 = 6-rayed
8 = 5-rayed
9 = 4-rayed
A = 3-rayed
B = 2-rayed
C = reduced to a bristle (no rays)
D = six tenent hairs

**<u>53.</u>** Leg II: femur and genu articulation
0 = normally articulated
1 = division weak, almost fused
2 = not articulated, totally fused

**<u>54.</u>** Leg II: tibia presence
0 = present
1 = partly fused to tarsus
2 = completely fused to tarsus (absent)

## GENITALIA

**<u>55.</u>** Location of genital area
0 = caudally
1 = about 9-15 annuli removed from coxae, located posterior to setae *c2*
2 = close to, but not appressed to coxae
3 = appressed to coxae

**56.** Form of female internal genital apodeme
0 = homologous structure to eriophyoid female genital apodeme absent
1 = moderately extended to front (“normal”)
2 = folded up, appearing like a thick transverse line
3 = folded up, but appearing slightly broader than a transverse line

**57.** Shape of spermathecae
0 = spermathecae homologous to the eriophyoid spermathecae absent
1 = round or ovalish
2 = elongated

**58.** Spermathecal tubes
0 = spermathecal tubes similar to those in the Eriophyoidea absent
1 = relatively short to very short (normal)
2 = long

**59.** Female genital coverflap
0 = absent
1 = entirely unornamented
2 = entirely unornamented, but divided into a basal and distal area (e.g. *Hoderus roseus*)
3 = basally ornamented, distally unornamented (smooth)
4 = basally unornamented (smooth), distally ornamented
5 = entirely ornamented, divided in basal and distal area
6 = entirely ornamented, not divided in basal and distal area

# Appendix F.

Data matrix of morphological characters for 64 eriophyoid species and two outgroup species (*Orphareptydeus* and *Mononychelus*) for the 66tax analyses. ? = uncertain or unknown character states, - = inapplicable states.

**APPENDIX F.**

| | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 |
| *Orfareptydeus stepheni* | 0000330060 | 0000000000 | 000221010? | 1?0??00000 | 010?340008 | 1000000000 |
| *Mononychelus yemensis* | 2200030060 | 00000000?0 | 000100000? | 0?0??00000 | 010?340008 | 1CD0000120 |
| *Abacarus acalyptus* | ?210331241 | 0100001100 | 0005220000 | 1222246201 | 1011233002 | 3170021116 |
| *Aberoptus samoae* | ?210331231 | 0100201220 | 01??230000 | 110??4B100 | 110?003301 | 09C0033116 |
| *Acadicrus bifurcates* | 0210331211 | 0100201100 | 0005220000 | 1221B46500 | 110?233003 | 4170021113 |
| *Acalitus ledi* | 2210331041 | 0100201301 | 01??220000 | 1A0??43100 | 110?233002 | 1180021115 |
| *Acamina nolinae* | 0210331011 | 0111201011 | 0003221000 | 1222647501 | 1011004003 | 3180021115 |
| *Acaphyllisa parindiae* | 0210?41021 | 0100201110 | 0020220000 | 1222347631 | 100?133002 | 24A0021115 |
| *Acaricalus segundus* | 0210341011 | 0100201000 | 0004220000 | 1722147201 | 100?002002 | 2590021115 |
| *Acathrix trymatus* | 0200551200 | 0100001110 | 0003120000 | 120??41100 | 110?113002 | 2120021211 |
| *Aceria tulipae* | 0210211241 | 0100001010 | 0004220000 | 120??41100 | 110?233002 | 1160021116 |
| *Acritonotus denmarki* | 0210341211 | 0100201000 | 0002220000 | 1222117821 | 100?003005 | 49A0021115 |
| *Aculops populivagrans* | 0210331241 | 0100201210 | 0005220000 | 1222436600 | 120?233002 | 3190021116 |
| *Aculus ligustri* | 0210331241 | 0100001100 | 0005220000 | 1222236600 | 1[02]0?203002 | 4190021116 |
| *Acunda plectilis* | 0210331241 | 0100001010 | 0002220000 | 120??41401 | 110?103002 | 1150023116 |
| *Aequsomatus lanceolatae* | 0210331011 | 0100112?00 | 0006220000 | 1222146400 | 120?133002 | 31A0021??1 |
| *Anthocoptes gutierreziae* | 0210341241 | 0100001210 | 0004220000 | 1322237730 | 100?233002 | 2190021115 |
| *Apodiptacus cordiformis* | 0210331211 | 0100201001 | 0004221001 | 2222947611 | 1011234003 | 3590021215 |
| *Asetacus madronae* | ?211??10?1 | 0100201011 | 0003221001 | 2922745200 | 1014204004 | 3170021115 |
| *Calacarus pulviferus* | 0211??2??1 | 0100201110 | 0004220100 | 1222145201 | 1012233002 | 3190021115 |
| *Catarhinus tricholaenae* | ?210341011 | 0100201121 | 0000230001 | 2222837611 | 110?233002 | 1170021113 |
| *Cecidophyes rouhollahi* | 0211??2??1 | 0100201300 | 0003220000 | 1212145200 | 110?103002 | 2180032115 |
| *Cenaca syzygioidis* | 2210321241 | 0100212?01 | 01??220000 | 120??31100 | 110?003001 | 1190021116 |
| *Cenalox nyssae* | 0210331251 | 0100201300 | 0002220000 | 1222437501 | 110?002002 | 1190031111 |
| *Chakrabartiella ficusis* | 0210331201 | 0100012?01 | 0006221001 | 210??15501 | 110?003002 | 3180021114 |
| *Cheiracus sulcatus* | 0210341251 | 0100201000 | 0014220001 | 2B22147611 | 100?233002 | 3000021113 |
| *Colomerus gardeniella* | 0210331211 | 0100201300 | 0004220000 | 120??41100 | 110?003002 | 1180032115 |
| *Colopodacus africanus* | 0210341021 | 0100201300 | 01??220000 | 1322146101 | 110?00302? | ?180221113 |
| *Cosetacus camelliae* | 0210221241 | 0100201400 | 01??220000 | 120??43100 | 110?003002 | 1170033115 |
| *Dechela epelis* | 0211??2??1 | 0100212?00 | 01??250100 | 1312643100 | 110?233001 | 13[678]0032116 |
| *Dicrothrix anacardii* | 1210341011 | 0110201000 | 0016220000 | 1622147403 | 100?003002 | 3290021111 |
| *Diptacus sacramentae* | 0210331211 | 0100201011 | 0000221001 | 2222146600 | 1212113004 | 3570021111 |
| *Diptilomiopus assamica* | ?211??10?1 | 1200212?11 | 11??221111 | 2211145501 | 100?233202 | 1582021111 |

| | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 | 0123456789 |
| *Diptilomiopus averrhoae* | ?211??10?1 | 1200212?01 | 11??221101 | 210??45501 | 100?203202 | 1552021111 |
| *Diptilomiopus jevremovici* | ?211??10?1 | 1200112?01 | 11??221111 | 220??45501 | 160?233202 | 1572021115 |
| *Epicecidophyes clerodendris* | 0210341021 | 0100201000 | 0003220100 | 1222135621 | 100?003002 | 3180033116 |
| *Eriophyes pyri* | 0210221201 | 0100001100 | 0003220000 | 160??43100 | 110?215002 | 1190021?16 |
| *Eriophyes quadrifidus* | 0210331021 | 0100001200 | 0004220000 | 1222141100 | 110?233002 | 3190021115 |
| *Hyboderus roseus* | 0210341101 | 0100001011 | 0004221101 | 260??35600 | 100?123002 | 31[67]0021112 |
| *Knorella gigantochloae* | 2211??2??1 | 0111201001 | 0003221100 | 1822848671 | 100?233002 | 1580021113 |
| *Litaculus khandus* | 0210331011 | 0100201100 | 0004220100 | 1222346620 | 100?003002 | 1570021?15 |
| *Nalepella tsugifoliae* | ?110011011 | 0100001210 | 0002120000 | 1912245300 | 110?203006 | 5140021121 |
| *Neopropilus jatrophus* | ?201??2??0 | 0111201110 | 01??120000 | 182214B620 | 200???3002 | 2190021??1 |
| *Neorhynacus rajendrani* | 02104410[12]1 | 1200101101 | 0000221101 | 210??46501 | 110?222002 | 4580021113 |
| *Nothopoda rapaneae* | 0210331241 | 0100212?00 | 01??220000 | 160??41100 | 110?23202? | ?190221115 |
| *Novophytoptus stipae* | 2200001241 | 0100001041 | 0005221000 | 120??44100 | 110?233002 | 4290012211 |
| *Paracalacarus podocarpi* | 0211??2??1 | 0100101111 | 0001221100 | 1612145511 | 110?233002 | 3190021115 |
| *Paracolomerus casimiroae* | 0210321241 | 0100001400 | 0004220000 | 120??41100 | 110?203002 | 1180022111 |
| *Pareria fremontiae* | ?210331201 | 0100001100 | 0004220000 | 120??41800 | 110?233002 | 2180021115 |
| *Pentamerus rhamnicroceae* | 0210331241 | 0100001010 | 0004220000 | 1222446601 | 1412233002 | 3180021116 |
| *Pentasetacus araucaria* | 0100331000 | 0100001220 | 0004120000 | 1922233100 | 110?003002 | 25A0021?21 |
| *Phantacrus lobatus* | 0110011201 | 0100001110 | 0002120000 | 1222846654 | 100?233005 | 5160021121 |
| *Phyllocoptruta arga* | 2210331251 | 0100201400 | 0002220000 | 1322847601 | 160?112002 | 11A0021115 |
| *Phyllocoptruta oleivora* | 0210331021 | 0100101110 | 0004220000 | 1622147611 | 100?233002 | 1180021115 |
| *Phytoptus avellanae* | 0200331010 | 0100001010 | 0005220000 | 120??41100 | 110?133002 | 11[89]0023213 |
| *Prothrix aboula* | 0001??2??0 | 0110201310 | 01??120000 | 1822117601 | 200?002002 | 418003??11 |
| *Retracrus johnstoni* | 0200341041 | 0110201020 | 1002120100 | 182211A631 | 2012002002 | 4170021111 |
| *Rhynacus arctostaphyli* | ?211??12?1 | 1200112?01 | 0004221101 | 210??46501 | 110?004002 | 1560021115 |
| *Rhyncaphytoptus ficifoliae* | ?210331201 | 0100001210 | 0004220001 | 2222646710 | 112?003002 | 2170021111 |
| *Schizoempodium mesophyllincola* | 0210341211 | 0100001000 | 0005220000 | 1B21843100 | 110?233002 | 3590022115 |
| *Sierraphytoptus alnivagrans* | 0200331010 | 0100001210 | 0004220000 | 1222137610 | 100?003002 | 31B0021211 |
| *Tegolophus califraxini* | 0210331041 | 0100201100 | 0006220000 | 1222245611 | 1[01]0?003002 | 3170021116 |
| *Tegonotus mangiferae* | 0210451221 | 0100001110 | 0001220000 | 1322347631 | 100?233002 | 3170021115 |
| *Thamnacus rhamnicola* | ?210331041 | 0100201110 | 0005220000 | 1222137611 | 100?003002 | 3190021??6 |
| *Trisetacus ehmanni* | 0110221100 | 0100001120 | 0003120000 | 160??41100 | 110?111002 | 1160021121 |
| *Vasates quadripedes* | ?210??1051 | 0100201000 | 0004220000 | 1222846610 | 110?233001 | 1570021115 |