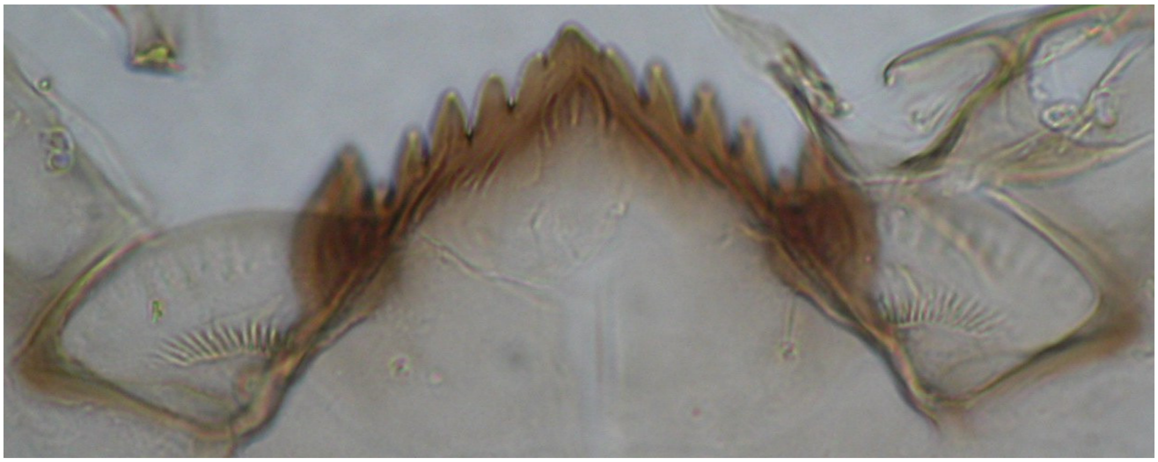
Guide to Identification and Ecology of New Zealand Subfossil Chironomids Found in Lake Sediment



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Contact Ann Dieffenbacher-Krall to request this guide on CD.
Comments on this guide will be most welcomed.

Drawings by Dieffenbacher-Krall. Photographs by Dieffenbacher-Krall, Vandergoes, and Woodward.

This taxonomic guide is a result of work to build New Zealand subfossil chironomid training sets to enable quantitative environmental reconstructions from chironomid larvae head capsule (Dieffenbacher-Krall et al. 2007, Woodward and Shulmeister 2006). We offer this guide as a taxonomic reference for anyone working with subfossil chironomids from New Zealand or other Southern Hemisphere locations, particularly in the fields of ecological and environmental analysis and reconstruction. The guide will be updated periodically as our research progresses.

We have made this subfossil taxonomy as consistent with the current full organism taxonomy for New Zealand as possible. We have opted to use a numbering system for unnamed Orthocladiinae rather than the lettering system of Boothroyd (unpub.) because numbers are unlimited. Synyonmy with Boothroyd's lettered Orthocladiinae is noted on individual pages. In many cases, the name given to a subfossil taxon was determined by examination of Boothroyd's mounts of modern larvae. We have been conservative in naming the taxa. For some New Zealand taxa there is only one species known from full organism studies. We have not used species names unless subfossil head capsules typically contain a feature distinguishing the species from other species within the genera, whether other species are found in New Zealand or not. We have not attempted to synchronize this taxonomy with the descriptions and photographs provided by Boubee (1983) and Schakau (1993) because we are not able to examine the original material. We prefer to avoid misclassification that might result from relying solely on verbal descriptions or single-view photographs provided in their theses, which may not show features critical to diagnosis of some taxa.

At this point in time, this guide is based exclusively on South Island material, although many of the types can certainly also be found on North Island, or smaller New Zealand islands. We currently recognize 60 subfossil types, of which 22 are Chironominae (5 of which are Tanytarsus funebris types), 2 are Diamesinae, 30 are Orthocladiinae, 1 is Podonominae, and 5 are Tanypodinae

Numbered Orthocladiinae:
In an effort to standardize subfossil chironomid taxonomy across at least a portion of the Southern Hemisphere, we have coordinated our unnamed Orthocladiinae numbering with Julietta Massaferro (Universidad de Bariloche, Argentina), who is currently developing a similar guide for South America. Missing numbers represent either taxa found in South America but not in New Zealand, or taxa for which we were finally able to assign a name. Retired numbers are not reused to avoid confusion.

Lakes:
Most numbered lakes listed in this document are described in Dieffenbacher-Krall et al. (2007). A few were not included in that article and information about these additional sites can be requested from Dieffenbacher-Krall. Named lakes are described in Woodward and Shulmeister (2006). For chironomid taxa found only in late-glacial age sediment, we have named the lakes. Descriptions of late-glacial chironomid studies will be forthcoming over the next several years. "Reference" describes slides made with

one head capsule per slide for the purpose of developing the taxonomy (Vandergoes and Dieffenbacher-Krall, unpub.).

We are currently working together to establish taxonomic consistency between the two inference model studies (Dieffenbacher-Krall et al. 2007, Woodward and Shulmeister 2006) based on this guide. The training sets from the two studies will then be combined. Woodward and Shulmeister (2006) lakes noted in this taxonomic guide include only those which we (Woodward, Vandergoes, and Dieffenbacher-Krall) have recounted using this standardized taxonomy. We have completed recounting 15 of the Woodward and Shulmeister (2006) sites and will update this guide as we complete more. Some of the Woodward and Shulmeister (2006) lakes were deemed inappropriate for the combined training set (e.g., too big, too much obvious human impact) and were excluded. Recounted lakes to date are Iron, Sylvester, Little Sylvester, Rainbow Skifield W, Rainbow Skifield E, Sedgemere, Princess Bath, Emma, Sylvan, Harris, Mackenzie, Gertrude Saddle/Black, Howden, Sugarbowl Tarn, and Alta.

Ecological information:
We have provided GLM models (using Canoco) for mean summer temperature (SmT), log10 chlorophyll a (Chla), log10 conductivity (CON), and log10 percentage sediment organic content (ORG; based on 550 °C, 2 hour, loss on ignition) for all taxa (using square root of percentages) for which there is a significant ($p<0.005$) relationship, including only lakes from Dieffenbacher-Krall et al. (2007). When we have completed combining the two training sets, we will repeat the analyses including Woodward and Shulmeister (2006) lakes and update these pages. Methods were described by Dieffenbacher-Krall et al. (2007). Optimum and tolerance is indicated if calculated. We also generated HOF models (Huisman et al. 1993) for SmT for taxa found in a minimum of 10 sites (http://cc.oulu.fi/~jarioksa/; Oksanen and Minchin 2002). A Roman numeral in the corner of the graph indicates the HOF model type. For those taxa for which we have sufficient data, we provide a verbal description of subfossil ecology based solely on the sites described in Dieffenbacher-Krall et al. (2007). Subfossil chironomid ecology in lakes that are different from those included in that data set, such as North Island, highly eutrophic or disturbed, less than one meter deep, or large, may be quite different. Additional subfossil ecological information observed by Woodward and Shulmeister (2006) is noted where provided.

The data for the two training sets was collected using the same methods, but the suite of lakes included in each study is somewhat different. The altitudinal and temperature ranges of the two sets of lakes overlap, but the Dieffenbacher-Krall et al. (2007) set extends to a higher altitude and lower mean February temperatures than the Woodward and Shulmeister (2006) lake set. The latter has broader ranges of chlorophyll a and conductivity than the former (Table 1). Both studies avoided lakes with obvious human impacts.

Note well: *Subfossil head ecology and full larvae ecology are not the same.* Issues of taphonomy, how larvae head capsules are deposited and preserve in sediment, necessitate modern studies based on the subfossil assemblage from sediment taken from the deepest part of lakes. Whole organism studies of the larval, adult, or pupal life phases may be biased with respect to season of sampling or sampling location within a lake. The preservable subfossil head capsules are extremely small and light weight and the remains of both littoral and profundal species become incorporated in deep water sediments (Iovino 1975, Wiederholm 1979, Brodin 1982, Boubee 1983, Schmäh 1993). The top half-centimeter of sediment contains subfossil material deposited over a number of years, whereas full organism sampling generally includes only those individuals living at the time of sampling. Typically, a far greater number of taxa are found by subfossil sampling than by full organism sampling.

Table 1. Range of values for various environmental variables for lakes included in Woodward and Shulmeister (2006) and Dieffenbacher-Krall et al. (2007) studies.

	# sites	Altitude m a.s.l	lake depth m	# taxa/lake		SmT	Mean Feb. temp	Chla	CON
		min-max	min-max	min-max	mean	°C	°C	mg/m^3	µS/cm
Woodward and Shulmeister 2006	46	20-1882	0.74-40	1-21	10.5	n/a	8.2-18.1	0.15-181	6.9-1180
Dieffenbacher-Krall et al. 2007	61	120-2070	1-37	3-20	11.6	6.4-15.2	7.4-15.8	<0.1-5.9	3-96

We have provided ecological information gleaned from other sources. Note, this information is based on full organism studies unless otherwise noted. Extreme caution must be exercised when using this information to interpret subfossil assemblages.

Although researchers who study New Zealand chironomids at the organism level have been extremely productive, the size of the country and the great variety of habitat types relative to the number of researchers leave much room for continued research. Research about chironomid ecology remains in its infancy.

Definitions/Abbreviations:

cephalic setation - pattern of spots on Tanypodinae head capsules formed by pores and hair bases
Chla – chlorophyll a
CON - conductivity
Laterals - side teeth
Median - central tooth or teeth
Mentum - full set of teeth
NI – North Island
ORG – organic content (% loss-on-ignition, 550 °C, 2 hours)
SI – South Island
SmT – mean summer temperature (January, February, March)
VMP - ventromental plate
POP – post occipital plate

Additional taxa that are apt to occur in New Zealand lake sediment:
We have included only those taxa which we found represented in the subfossil assemblage. Additional taxa reported from New Zealand full organism studies that might be found as subfossil heads follow. We would greatly appreciate notification if other researchers find these or other taxa not included in this guide.

Chironominae Tanytarsini *Stempellina* (Boothroyd unpub., Stark and Winterbourn 2006): Trifid (notched) median, 6 laterals. 1st lateral smaller than 2nd. VMP striated with serrated edge. Antennae pedestals have multi-branched spurs. Known from springs and seepages in Waikato region. Found by Schakau (1993) in Lake Monowai.

Diamesinae *Heptagyini* (Stark and Winterbourn 2000): Head capsules tentatively referred to as *Heptagyini* sp. I were found by Schakau (1993) in Lady Lake. Schakau described them as having double median teeth and 5 laterals, VMP present, no beard.

Diamesinae *Lobodiamesa* (Boothroyd unpub., Boothroyd and Forsyth 2007, Stark and Winterbourn 2000): Single, broad, smooth, rounded median, 7 laterals. One species, *L. campbelli*, found occasionally in small mountain streams. A second species known from Waikato.

Orthocladiinae *Camptocladius* (Boothroyd unpub., Stark and Winterbourn 2000, Boothroyd and Forsyth 2007): Single, broad, rounded median, about same height as 1st lateral. 4 laterals. One species, *C. stercorarius*, is common, widespread, terrestrial, found in cattle dung.

Orthocladiinae *Cricotopus hollyfordensis* (Boothroyd 2002): Single median, 6 laterals. Median tooth rounded, more than 1.5 times wider and less than 1.5 times taller than 1st lateral.

Orthocladiinae *Cricotopus vincenti* (Boothroyd 2002): Single median, 6 laterals. Median slightly flattened. Laterals 1 and 2 partially fused with median.

Orthocladiinae D “Pear” (Boothroyd unpub.): Double (bifid) median, 5 laterals. Mentum sharply sloped.

Orthocladiinae F “Coastal” (Boothroyd unpub.): Single median, 6 laterals. 3rd laterals taller than 1 and 2. Peg-like seta subdentalis on mandibles.

Orthocladiinae H “Chapel” (Boothroyd unpub.): Single, pointed median, 5 laterals. 1st lateral is very short, 2nd lateral as tall as median and broader than other laterals. Laterals 3-5 descend in size and are thinner than 2. Known from Coromandel Peninsula.

Orthocladiinae I (Boothroyd unpub.): Double (bifid) median, 5 laterals. Laterals 3-5 small and clustered.

Orthocladiinae *Stictocladius* (Boothroyd unpub., Boothroyd and Forsyth 2007): Single, broad, rounded median is much taller than laterals. 4 laterals, 1st lateral taller than other 3. Laterals 2-4 are clustered together. Two species, *S. lacuniferus* and *S. pictus*, found throughout New Zealand, generally in small mountain and hill country streams, occasionally in lowland streams.

Orthocladiinae *Tonnoirocladius commensalis* (Cranston 2007): This is the *"Dactylocladius" nomen dubium* (Boothroyd unpub.): Single, broad, rounded median, 6 laterals. 1st lateral nearly as tall as median. Laterals 4-6 are on a much lower plane than median and laterals 1-3. Bearded. Found throughout New Zealand, commensal with Blephariceridae larvae, usually in cold, swift, mountain streams.

Podonominae *Podochlus* (Boothroyd unpub., Stark and Winterbourn 2006): Bifid median, 8 or 9 laterals. 3rd lateral is taller than 1 and 2. 3rd inner tooth of mandible is longer than any other mandible tooth. Four species recorded from New Zealand, but larvae unknown, probably inhabiting swift mountain streams. Larvae fitting this description found in glacial streams in Westland.

Podonominae *Podonomus* (Boothroyd unpub., Stark and Winterbourn 2006): Single median, 8 laterals. Median is about the same size as laterals 1 and 2. Lateral 3 is larger than 1 and 2. 3rd inner tooth of the mandible is longer than the apical tooth. Seven species recorded for New Zealand but larvae unknown. Probably inhabit swift mountain streams. Reported from a water-filled leaf axil of New Zealand flax.

Podonominae *Zelandochlus* (Boothroyd unpub., Dumbleton 1973, Boothroyd and Cranston 1999): Single median is taller than 1st lateral. 9 laterals. Laterals 1 and 2 roughly equal in size, lateral 3 is taller. 1st inner tooth of mandible is larger than apical tooth. One species, *Z. latipalpis*, the "ice worm", known only from the surfaces of Fox and Franz Joseph Glaciers.

Tanypodinae Macropelopini *Gressitius* (Boothroyd unpub.) See Tanypodinae General Comments.

Tanypodinae Pentaneurini *Larsia* (Boothroyd unpub.): Might be our Pentaneurini 1.

Tanypodinae Pentaneurini Pentaneurini sp. A (Boothroyd unpub.): 4 toothed ligula with all teeth roughly equal in height, bifid paraligula. About 8 teeth on pecten hypopharyngis. Found upper North Island.

Tanypodinae *Zavreliymia* (Boothroyd unpub., Boothroyd and Forsyth 2007, Stark and Winterbourn 2006): Bifid paraligula with small basal tooth. 5 toothed ligula with central tooth being the shortest and outermost teeth angled outward. One species, *Z. harrisi*, found in streams and lakes.

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Checklist of New Zealand subfossil chironomid types

	Subfamily	**Tribe**	**Genus/species or type**
1	Chironominae	Chironomini	Chironomini 1
2			Chironomini early instar
3			*Chironomus* (2 pp)
4			*Cladopelma*
5			*Cryptochironomus*
6			*Harrisius*
7			*Kiefferulus*
8			*Lauterborniella*
9			*Microtendipes*
10			*Parachironomus*
11			*Paucispinigera*
12			*Polypedilum*
13			*Xenochironomus*
14	Chironominae	Pseudochironomini	*Riethia/Pseudochironomini*
15	Chironominae	Tanytarsini	*Corynocera*
16			*Paratanytarsus*
			Tanytarsus funebris types (4 pp)
17			Type A short
18			Type A long
19			Type B long
20			Type C short
21			Type C long
22			*Tanytarsus vespertinus*
23	Diamesinae		Diamesinae early instar
24			*Maoridiamesa*
25	Orthocladiinae		*Corynoneura*
26			*Cricotopus aucklandensis*
27			*Cricotopus planus*
28			*Cricotopus zealandicus*
29			*Eukiefferiella*
30			*Gymnometriocnemus* type
31			*Hevelius*
32			*Kaniwhaniwhanus*
33			*Limnophyes/Paralimnophyes*
34			*Naonella forsythi*

35			*Naonella kimihia* (2 pp)
36			*Naonella* type 305
37			*Naonella* type 419
38			nr*Kaniwhaniwhanus*
39			Ortho 1b
40			Ortho 3
41			Ortho 4
42			Ortho 5
43			Ortho 7
44			Ortho 8
45			Ortho 9
46			Ortho 12
47			Ortho 15
48			Ortho 16
49			Ortho 19
50			*Parakiefferiella*
51			*Paratrichocladius*
52			*Pirara*/Orthocladiinae E
53			*Smittia*
54			*SO4*
55	Podonominae		*Parochlus*
	Tanypodinae	General comments	(1 p)
56		Macropelopini	Macropelopini type 1
57		Macropelopini	Macropelopini type 2
58		Macropelopini	Macropelopini type 3
59		Pentaneurini	*Ablabesmyia*
60		Pentaneurini	Pentaneurini 1
	Non-Chironomid	Ceratopogonidae	
		Simuliidae	
		Culicidae	