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Martin Soesbergen
European Invertebrate Survey Netherlands, Karveel 12–38, 8231 AS Lelystad, Netherlands

Jos Sinkeldam
Wageningen University & Research, Droevendaalsesteeg 3a, 6708 PB Wageningen, Netherlands

Correspondence
Martin Soesbergen
European Invertebrate Survey Netherlands, Karveel 12–38, 8231 AS Lelystad, Netherlands

Filinia species in brackish waters at St. Maarten (Dutch Caribbean)

Martin Soesbergen and Jos Sinkeldam

Abstract
From a brackish lagoon on St. Maarten (Dutch Caribbean) plankton samples were collected from 2003 to 2005. The samples were taken and physical-chemical data were measured by the second author. The samples were analyzed by the first author. Three rotifers belonging to the *Filinia terminalis*-group were found. They differ in morphology from described species. The physical-chemical results show that the brackish habitat in which they are found is very deviating from their normal freshwater habitat. These differences suggest the presence of cryptic species. The results contribute to the knowledge of the morphology and the ecology of the *Filinia terminalis*-group. It is stressed that records of animals found outside the known geographical and ecological range should be accompanied with a good descriptions to prevent force fitting and, a priori, creating very eurytopic cosmopolitan species.

Keywords: rotifera, *Filinia* cf. *novaezealandiae, filinia* cf. *pejleri*, morphology, ecology

1. Introduction
The use of authoritative references such as Kutikova (1970) [1] and Koste (1978) [2] outside Europe must be seen as a contributing factor to 'cosmopolitanism' in the Rotifera" is the opening sentence of Shiel & Sanoamuang's description of *Filinia Novaezealandiae* in 1993. This is certainly true and extra caution is needed with plankton organisms from extreme or peculiar habitats. Records of *F. terminalis*, a stenothermic cold water species, in the tropics was the reason for Hutchinson (1964) [3] to distrust these identifications and led to the discovery and description of *Filinia pejleri*. Now Sanoamuang (2002) [4] is the authoritative references which is followed and two tropical cosmopolitan species have emerged: *Filinia pejleri* Hutchinson, 1964 and *Filinia Novaezealandiae* Shiel & Sanoamuang, 1993. *Filinia*-species found in hypertrophic brackish waters at St. Maarten resemble these two species. Three morphs were present and their morphology and ecology is discussed.

2. Materials and Methods
Samples were collected in 2003-2005 by the second author on St. Maarten. This island is part of the Kingdom of the Netherlands. The Dutch Caribbean consists of three countries: Aruba, Curaçao and St. Maarten and three special Dutch counties Bonaire, St. Eustatius en Saba (Fig. 1). Plankton samples were collected at five locations in the northeastern part of the island (Fig. 1). These locations are Fresh Pond North (18°02′06″N; 63°03′26″W), Fresh Pond South (18°01′48″N; 63°03′22″W), Little Bay Pond (18°01′18″N; 63°03′51″W), Great Salt Pond West (18°01′40″N; 63°03′08″W) and Great Salt Pond East (18°01′33″N; 63°02′27″W). Sometimes ocean water is supplied in Great Salt Pond and this causes fluctuations in salinity at sampling point Great Salt Point East. Great Salt Pond West is connected with sampling point Fresh Pond South. Little Bay Pond is an isolated water.

Fig 1: Dutch Caribbean, red special counties and black countries. Sample locations on St. Maarten. 1–Fresh Pond North, 2–Fresh Pond South, 3–Little Bay Pond, 4–Great Salt Pond West and 5–Great Salt Pond East.

The samples were taken with a plankton-net with 50 µm mesh width. Samples were taken in open water. The net was thrown in and towed through about 10 meter water. The residue was rinsed out with 4% formaldehyde to get a preserved sample. At each location temperature (°C), oxygen (mg/l and %), electric conductivity (EC_{25}), salinity (ppt) and pH was measured. Samples were taken in February, June, October and December in 2003, March, June, September and December 2004, March and June 2005. In total 52 samples were analyzed. Specimens were identified under an inverted light microscope (Olympus IM70) using the inverted microscope method (Hasle 1978) [5]. From a sample 1 ml was pipetted in a 5 ml Hydro-Bios cuvette and supplemented with distilled water and covered with a cover-glass. Identification was done with Sanoamuang (2002) [4]. In addition Hutchinson (1964) [3] and Shiel & Sanoamuang (1993) [6] were used. Photographs were taken with Olympus Cell Sense software.

3. Results

Filinia-species are found in Fresh Pond and Little Bay Pond. They all have an immovable caudal seta and belong to the *Filinia terminalis*-group (Sanoamuang, 2002) [4]. Three morphs are present. The morphs differ in body shape, length of the setae, the position of the insertion of the caudal seta (Figure 2) and the width of the caudal seta at its basis (Figure 3). The most common morph resembles *F. Novaezealandiae* and *F. terminalis* (Sanoamuang, 2002) [4]. Both other morphs key out as *F. pejleri* by having a terminally inserted caudal seta and being less than 200 µm large. They are hereafter called *F.* cf. *Novaezealandiae*, *F.* cf *pejleri* 1 and *F.* cf *pejleri* 2.

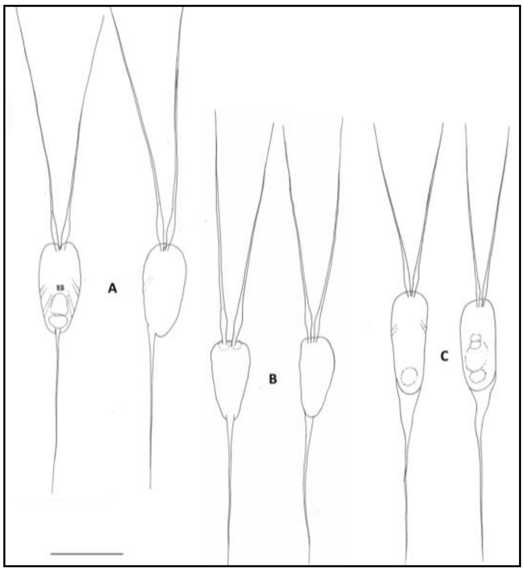

Fig 2: A–Ventral and lateral view of *F.* cf. *Novaezealandiae*, **B** - *F.* cf *pejleri* 1 and **C** - *F.* cf cf *pejleri* 2. Scale bar = 100 µm.

F. cf. *Novaezealandiae* is the most abundant morph. It was found in the samples from Fresh Pond from February to December 2003 and also in June 2004 (Table 1). It is a little less abundant in Fresh Pond South which is connected with Great Salt Pond. It was only once (December 2003) found in Little Bay Pond when salinity dropped below 1.8. *F* cf. *pejleri* 1 was always present in lower numbers (Table 1). *F.* cf *pejleri* 2 was found in September 2004 and was still present in Fresh Pond North when salinity was higher (Table 1). The presence of this two species coincide with lower salinities e.g. fresh (S< 1.3) to oligohaline (S 1, 3–2, 6) water. *F.* cf *pejleri* 2 was found at salinity 1.3 – 3.1 and is an oligohaline to slightly α-mesohaline (2, 6–10, 7) species.

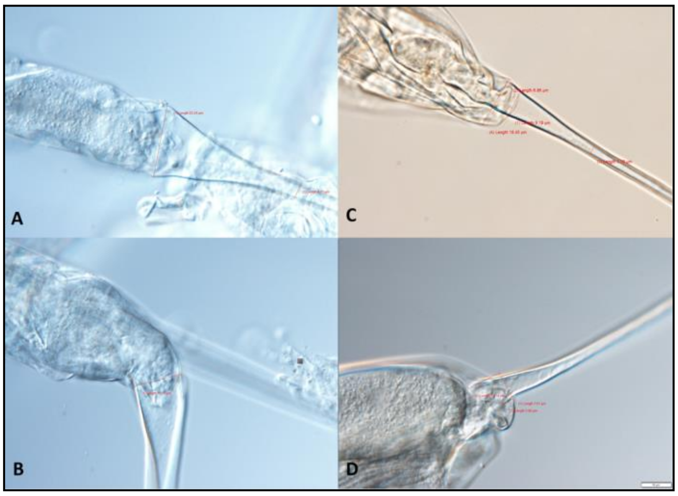

Fig 3: Basal insertion of the caudal seta: *F.* cf *pejleri* 2 (A dorsal and B ventral); C *F.* cf. *pejleri* 1 and D *F.* cf. *Novaezealandiae*.

Table 1: Presence of *F.* cf. *Novaezealandiae* (FN), *F.* cf *pejleri* 1 (FP1) and *F.* cf *pejleri* 2 (FP2). - absent, + very scarce, ++ common, +++ abundant. White – fresh / light green – oligohaline / green – α-mesohaline / dark green – β-mesohaline-salt water grey – not measured

Month Year	Great Salt Pond			Little Bay Pond			Fresh Pond North			Fresh Pond South		
	FN	FP1	FP2	FN	FP1	FP2	FN	FP1	FP2	FN	FP1	FP2
February 2003	-	-	-	-	-	-	++	-	-	+	-	-
June 2003	-	-	-	-	-	-	+++	+	-	+++	+	-
October 2003	-	-	-	-	-	-	+	-	-	+	-	-
December 2003	-	-	-	++	+	-	+++	+	-	++	+	-
March 2004	-	-	-	-	-	-	-	-	-	-	-	-
June 2004	-	-	-	-	-	-	+	-	-	+	-	-
September 2004	-	-	-	-	-	-	-	+	+++	-	-	+
December 2004	-	-	-	-	-	-	-	-	+	-	-	-
March 2005	-	-	-	-	-	-	-	-	-	-	-	-
May 2005	-	-	-	-	-	-	-	-	-	-	-	-

Temperature, pH, conductivity and salinity is given. The range (min – max) and mean value are given from the samples in which the species were present (Table 2). Oxygen at the sampling locations varied from low in the early morning to high in the afternoon. This indicates that these species are adapted to varying oxygen values due to respiration of the algae mass in this very eutrophic lake. Year round the water temperatures are high and vary between 25 °C in March to 32 °C in September. These populations are warm stenothermic. As illustrated above these populations live in oligohaline circumstances.

Table 2: Range and mean of temperature, conductivity, salinity and pH for the three morphs. *F.* cf. *Novaezealandiae* (FN), *F.* cf *pejleri* 1 (FP1) and *F.* cf *pejleri* 2 (FP2).

	T			EC			S			pH		
	min	**max**	**mean**	**min**	**max**	**mean**	**min**	**max**	**mean**	**min**	**max**	**mean**
FN	26,4	31,8	29,1	2059	3318	2815	1,05	1,7	1,5	8,2	9,6	9,0
FP1	26,4	32,1	29,2	2059	2912	2441	1,05	1,5	1,3	8,2	9,3	9,0
FP2	26,1	32,7	28,8	2496	5751	3590	1,28	3,1	1,9	8.9	9.7	-

4. Discussion

In almost all ecological studies species are, properly, denominated according to authoritative keys. But small differences will often be unrecognized or taken for within species variation and are not taken into critical consideration. Here we discuss the morphological differences between the morphs we found and the keys used and the original species description. Also a comparison of the ecology of the morphs with *F. Novaezealandiae* and *F. pejleri* is given.

4.1 Morphology

F. cf. *Novaezealandiae*: body oval with an immovable caudal seta. Caudal seta inserted 1-11 µm from the end of the body. Caudal setae small at basis, less than 0.2 times body width. Setae with nodules and long spinules. Caudal setae 218-340 µm, lateral setae 363-613 µm. Lateral setae about 1.7 times as long as caudal seta. Body length 113-137 µm, Body 2.2 to 2.7 times as long as broad. The more long oviform body in resembles *F. terminalis*. *F. terminalis* is a cold stenotermic species. This species is a warm water species. Differs from *F. Novaezealandiae* in body shape, it is more slender and less saccate, has longer setae and lateral setae with nodules and long spines. The last property is not mentioned in the original description (Shiel & Sanoamuang 1993) [6]. Hochberg & Gurbuz (2007) [7] describe *F. Novaezealandiae* from Florida with short spinules. The Florida animals differ also from the original description in the shape of the eggs. The presence of cryptic species seems possible.

F. cf *pejleri* 1: body long inverted conical with an immovable caudal seta. Caudal seta (sub)-terminal. Caudal setae broad at basis and joins half the bottom of the body. Setae with very small nodules and short spinules. Caudal setae 217-290 µm, lateral setae 387-545 µm. Lateral setae about 1.7 times as long as caudal seta. Length 82-106 µm. Body 2.2 to 2.5 times as long as broad. The caudal seta is inserted 0-2 µm from the end of the body.

Differs from *F. pejleri* in the sometimes sub-marginal caudal seta, in *F. pejleri* it is always terminal (Hutchinson, 1964, Sanoamuang 2002) [3, 4]. The body is smaller and relatively broad at the top, inverted conical instead of fusiform (Sanoamuang 2002) [4]. The small spinules at the setae are mentioned in the original description (Hutchinson, 1964) [3].

F. cf *pejleri* 2: body cylindrical with an immovable caudal seta. Caudal seta inserted at the end of the body (0 µm from top). Caudal seta compassing the bottom of the body, ± 25 µm broad from dorsal view and ± 15 µm broad from ventral view. Caudal setae 312-362 µm, lateral setae 304-406 µm. Caudal end lateral setae about equal in length. Setae with small slender denticles. Length 136-164 µm. Body 2.7 to 3.5 times as long as broad. The shape of the caudal setae resembles *F.* grandis (Sanoamuang 2002) [4]. The almost equal length of the setae differs from all four described species of the *F. terminalis* group. *F.* cf *pejleri* 2 differs from *F. pejleri* in body shape: cylindrical and longer more slender body, caudal and lateral setae equal in length, much broader basis of caudal setae. Trofi (mandibles) should be examined to have certainty about the status of this morph (Sanoamuang, 1993) [8].

4.2 Ecology

The measured chemical values (table 2) are compared with those found in literature on *F. Novaezealandiae* and *F. pejleri*. Reports on species from the *F. terminalis*-group in brackish environments are rare. *F. terminalis* is recorded from a broad range in salinity (0, 75 g/l–6.02 g/l) in Chany Lake (Kipriyanova *et al.*, 2008) [9]. In the tropics *F. terminalis* was recorded in a brackish lagoon in Rio de Janairo (Murray, 1913) [10].

The type locality *F. Novaezealandiae* is Lake Okaro (New Zealand), an highly eutrophic volcanic lake (Shiel & Sanoamuang, 1993) [6]. It was present in spring and summer at temperatures > 20°C. It is a limno-planktonic species (Shiel, 1981) [11]. *F. Novaezealandiae* is reported from a brackish flood plain in Argentina (Chaparro *et al.*, 2011) [12]. All other records indicate a stenotherm warm water species from fresh eutrophic habitats. Our records from *F.* cf. *Novaezealandiae* confirm the presence of *Novaezealandiae* like morphs in brackish waters.

The type locality of *F. pejleri* is Ootacamund (India) in an artificial lake with neutral water at 17,5 °C and in the Ruitenkuil Pan (Transvaal) it was found in slightly alkaline waters (Hutchinson, 1964) [3]. Records come from dis-, oligo- to mesotrophic fresh waters (Sanoamuang, 2002) [4] and show a wide range in temperature and pH. Both pejleri like morphs are found in a totally deviating environment: hypereutrophic and brackish. Ecological differences are considered to be important for species recognition in Filinia (Koste, 1978, Sanoamuang, 1992) [2, 13]. The ecological differences are too large to consider them one species. The possibility of cryptic species in this group was suggested by Sanoamuang (1992) [13] and Glime (2017) [14].

5. Conclusion

The differences between *F.* cf *Novaezealandiae* and *F. Novaezealandiae* are small, but the original description is short and insufficient to conclude these are the same. The small morphological differences alone are not enough to separate them, but the ecological differences are too large to consider them one species.

The differences between *F.* cf *pejleri* 1 and *F. pejleri* are small. The original description fits on the found morph. It is an oligo-mesotrophic species found in fresh water. The presence in a hypereutrophic and brackish lake seems to indicate a cryptic species.

The differences between *F.* cf *pejleri* 2 and *F. pejleri* are large and to our opinion too large to decide that this morph is the same as *F. pejleri*.

The animals belong to of the *Filinia terminalis*-group. The differences in morphology, together with the remarkable habitat suggest the presence of cryptic species. Lumping these morphs into the two known ‘cosmotropical’ species is, because of these differences, not justified. These findings stress the importance of making good descriptions of animals found outside their ‘normal’ geographical or ecological range. Important because force fitting, fitting animals that look like a described species into this species, makes very eurytopic cosmopolitan species. This is undesirable because it distorts our view of their distribution, the biodiversity of areas, interferes with biological assessments and is taxonomically wrong.

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