



Historical trends in the species inventory of tintinnids (ciliates of the microzooplankton) in the Bay of Villefranche (NW Mediterranean Sea): Shifting baselines

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Abstract

In the Bay of Villefranche, tintinnid ciliates have been studied since 1879 yielding a unique time series. The species inventory, excluding likely synonymous records, numbers 108. Temporal increases in the inventory appear linearly related to sampling effort up until the 2000s with a cumulative sampling effort of about 200 dates. Subsequently, with a large increase in sampling to currently over 460 dates, the rate of increases in species numbers declines. Surprisingly, the inventory is not highly inflated by unique occurrences, as species found but once are only 17 out of the 108. However, in recent years many previously recorded taxa have not been seen. Missing from a species list derived solely from intensive sampling from 2013 to 2016 are 38 previously recorded species. Most (26 out of 38) were recorded from a single year and thus may have been temporary residents. However, 12 species were found in multiple years by different investigators suggesting relatively common occurrence in the past. The substantial effort required to adequately sample a locality and possible historical changes in species inventories suggest that claims of a species as 'new' to a locality should be made with caution & caveats.

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Introduction

Currently there is considerable interest in changes in species distribution related to climate change and the phenomenon of invasive species. Recent reviews include reports of 'new' marine protists in British waters (e.g. [Minchin et al. 2013](#)) and in the Adriatic Sea ([Langer and Mouanga 2016](#); [Pecarevic et al. 2013](#)). With regard specifically to tintinnid ciliates, several species from the Mediterranean Sea have been catalogued as newly invasive species in the Black Sea ([Nunes et al. 2014](#); [Shiganova et al. 2012](#)), and conversely, as potential new introductions into the Adriatic from Black Sea ballast

water ([David et al. 2007](#)). Apparent changes in distribution in the North Atlantic over the past 50 years have been reported for some species of tintinnids ([Hinder et al. 2012](#)).

Obviously identification of a species as new to a given area requires near complete knowledge of the species inventory of the system or locality under consideration. However, species checklists, at least with regard to planktonic protists, are generally based either on a single time series of samplings, generally 1–3 years maximum, conducted with a single sampling protocol and acknowledged as provisional (e.g. [Hoppenrath 2004](#)) or alternatively are based on a wide-ranging literature review encompassing reports both historical and current, and are assumed to be comprehensive (e.g. [Gómez and Boicenco 2004](#)). In neither case is the

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Table 1. Summary data of tintinnid studies in the Bay of Villefranche.

Year	# samplings	Method	Reference (Table 2 number)
1879	10	Net	Fol (1881) (1)
1880	10	Net	Fol (1883) (2)
1929	5	Net	Balech (1959) (3)
1938	1	Net	Balech (1959) (3)
1939	2	Net	Balech (1959) (3)
1948	5	Net	Balech (1959) (3)
1949	1	Net	Balech (1959) (3)
1951	2	Net	Balech (1959) (3)
1953	12	Net	Balech (1959) (3)
1960	6	Net	Posta (1963) (4)
1961	50	Net	Posta (1963) (4)
1962	40	Net	Posta (1963) (4)
1973	52	Net & bottle	Rassoulzadegan (1975) (5)
1998	6	Bottle	Cariou et al. (1999) (6)
2002	47	Bottle	Dolan et al. (2006) (7)
2003	18	Bottle	This study (8)
2009	1	Bottle	Bachy et al. (2013) (9)
2010	12	Bottle	Dolan and Stoeck (2011) (10)
2013	29	Net & bottle	Dolan (2016) (11)
2014	50	Net & bottle	Dolan (2016) (11)
2015	57	Net & bottle	This study (8)
2016	37	Net & bottle	This study (8)

possibility of historical changes addressed. To assess the possibility of a species being ‘new’ to a locality or indeed of any changes in species distributions a baseline for comparison is needed. To our knowledge, only reports of temporal changes in species inventories with regard to planktonic protists are that of [Gavrilova and Dolan \(2007\)](#) on Black Sea tintinnids based on reports from scattered locations and [Modigh and Castalado \(2002\)](#) for the Bay of Naples that compared recent sampling to that of [Issel \(1934\)](#). There appears to be a single study concerning historical trends from a single locale; it concerned macroinvertebrates from a large coastal embayment and concluded that human activity, in particular harvesting, had changed the species inventory ([Trott 2016](#)). Here I report on historical changes in species inventory of tintinnid ciliates in a single location, the Bay of Villefranche, arguably the best-studied location with regard to tintinnid ciliates.

Studies of tintinnid ciliates in Villefranche began with the classic work of [Fol \(1881, 1883\)](#) who described new species based on sampling in 1879 and 1880. Fol’s work, and the subsequent and current work summarized in [Table 1](#), provides data allowing construction of a time-series of species lists and cumulative sampling effort (estimated as the number of samplings) of over 460 samplings over 137 years. Here I document the historical growth in the tintinnid species inventory, relate it to sampling effort, and examine apparent changes in community composition found in recent years compared to the historical record. The results suggest firstly that compiling a reasonable species inventory, i.e. species numbers approach a plateau with increased sampling effort, requires a

very considerable sampling effort, and secondly that changes in species inventories with time apparently occur.

Material and methods

Data characteristics

Literature reports (see [Table 1](#)) were the primary source of data. However, some unpublished data, i.e. continuations of 2 published temporal series (i.e. [Dolan et al. 2006](#); [Dolan 2016](#)), were included as well. Over the course of 137 years, sampling methods and sample analysis varied considerably and indeed in some instances protocols were not specified. Here the study methods are briefly described.

For the earliest reports ([Fol 1881, 1883](#)) samples were collected from unspecified locations in the bay using a custom made silk net, preserved with an iron perchloride solution, and examined using an immersion lens. According to the texts ([Fol 1881, 1883](#)), observations were made over 2 consecutive winters, 1879–1880 ([Fol 1881](#)) and 1880–1881 ([Fol 1883](#)). An arbitrary value of 10 dates sampled for each of 1879 and 1880 were assigned. The report of [Balech \(1959\)](#) concerns 28 net samples obtained from 1928 to 1953, without details on the type of net used, only notations as to month and year of the sample, and occasionally depth strata sampled. Balech gave no details as how samples were preserved nor analyzed. [Posta \(1963\)](#) analyzed samples obtained using a phytoplankton net (50 µm mesh) at Point B, the now standard Villefranche sampling location; the net tow is described only as ‘horizontal’.

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