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Wikiplantbase #Toscana, breaking the dormancy of floristic data

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Abstract

The online platform “[Wikiplantbase #Toscana](#)” provides a framework where the full set of georeferenced floristic records of Tuscany (central Italy) can be entered, stored, updated and freely accessed through the Internet. As of 5 January 2015, the database stores 67360 floristic records, referable to 3578 accepted specific and subspecific taxa. Most records are based on published data (80.6% of the total), then by published herbarium specimens (15.1%) and on unpublished field data (3.8%); unpublished herbarium records account only for 0.5% of the stored data. At present the most represented species is the fern *Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum* (Dennstaedtiaceae) with 234 records for 219 localities, but 625 species are still represented only by one record for a single locality. Data acquisition is far from complete, but in slightly more than one year a massive amount of data was accumulated, and can be maintained up-to-date with relatively little effort. This could power several researches like e.g.: 1) taxonomic researches especially on species and genera in Tuscany and Italy; 2) studies on the distribution of diversity across administrative or ecological boundaries; 3) evaluation of conservation status of endangered taxa; 4) static and dynamic range modelling and evolution niche studies.

Keywords: biodiversity informatics, database, floristic data, georeferencing, Italy, online platform, phytogeography

Introduction

Online databasing of plant diversity data became one of the major issues in biodiversity informatics in recent years. An increasing number of databases is now available concerning nomenclature and taxonomy (Euro+Med 2006 onwards, The Plant List 2013 onwards, IPNI 2014), herbarium specimens (anArchive 2003 onwards), invasive alien plant monitoring (SISSI 2014), ecology (Kleyer et al. 2008, Kattge et al. 2011), vegetation (Dengler et al. 2011, Landucci et al. 2012, Schaminée et al. 2012, Šibík 2012, Willner et al. 2012), chromosome numbers (Bedini et al. 2012, Peruzzi and Bedini 2014, Rice et al. 2014), plant rDNA sites (Garcia et al. 2012), genome size (Garcia et al. 2013), DNA sequences (Benson et al. 2013). On the contrary, there are still few publicly available databases storing floristic data, especially at local level: GBIF (<http://www.gbif.org/> – or the BioCASE – <http://www.biocase.org/>) aggregates a large number of primary biodiversity records for the whole world, yet when searching for floristic records (kingdom Plantae) in the minimum convex polygon enclosing Tuscany, only 2224 records are found. Floristic records provide baseline data for researches in plant biology, linking a certain systematic unit to the localities where it is known to occur. Traditionally, printed floras are the “one-stop-shop” to find floristic data for a territory; unfortunately, printed floras are quickly outdated. Therefore, researchers must look for updated data in the scientific literature and herbarium specimens: the longer the time elapsed since the issue of the flora, the heavier the effort. Tuscany (central Italy) is one of the richest Italian region on floristic grounds, either on quantitative or qualitative points of view. According to the figures presented by Peruzzi (2010), this region hosts not less than 3541 specific and subspecific vascular plant taxa, i.e. about 45% of the whole Italian flora (alien species included). 191 taxa are Italian endemics and 59 of them are narrow Tuscan endemics (Peruzzi et al. 2014).

Despite this exceptional plant diversity richness, the last regional flora dates back to the mid-19th century (Caruel 1860-1864, integrated by Baroni 1897-1908), followed – during the 20th century up today, by dozens of partial contributions concerning limited geographical areas or single taxonomic groups. Furthermore, a vast body of unpublished, yet reliable, data has been produced in the last two decades by an array of amateur, non-academic botanists who began to explore the regional territory – either individually or as member of formally established associations – to record local floristic data. Hence, any attempt to update such a regional flora must take into account the

acquisition of a vast, heterogeneous and “dormant” documentation, both published and unpublished, as well as any future inclusion or exclusion of taxa, synonymizations, new taxa descriptions, and so on.

We have started the project “[Wikiplantbase #Toscana](#)” (Peruzzi and Bedini 2013 onwards; Fig. 1) to provide a framework where the full set of georeferenced floristic records of Tuscany can be entered, stored, updated and freely accessed through the Internet.

Material and Methods

Data source

Plant nomenclature follows the on-going update of the Checklist of the Italian vascular flora (Conti et al. 2005, 2007, F. Conti and collaborators, in preparation); consequently, only records of vascular flora are accepted. To implement an automatic connection with Checklist names, these have been stored in a relational Postgresql 8.2 database (TAXBASE), constantly updated by one of the authors (LP) and currently including 8595 accepted names and 5739 synonyms. TAXBASE consists of three tables (NAMES, GENERA, FAMILIES): a recursive relation on the NAMES tables allows to match any specific/subspecific name with its corresponding accepted name. Georeferencing is aided by a place names database fed from SIRA (<http://sira.arpat.toscana.it/sira/Toponomastica/COMUNI.htm>) and from our own datasets, including provinces (3rd-level NUTS; European Commission 2011), municipalities (2nd-level LAU; Eurostat 2015), toponyms and WGS84 geographic coordinates, expressed in decimal degrees. Source referencing is supported by a publication database covering the years 1950-2005 (Scoppola and Magrini 2005), continuously expanded by the collaborators.

A basic record of Wikiplantbase #Toscana includes source type, source, taxon name as reported in source, georeferenced collection/observation place. Whenever possible, the taxon name reported in the source is verified in TAXBASE: the corresponding accepted name is then automatically inserted in a separate field, with no action required to users; when this is not possible (e.g. due to misspelled names or incomplete names), the accepted name is left blank and flagged for subsequent check by a project coordinator.

Data is entered via a HTML data entry form (Fig. 2; see Table I for a list of the entry fields) compatible with any common web browser. Several Javascript functions, linked to entry fields, enforce data homogeneity and integrity. All entered data are validated by a project coordinator. Upon validation, data are freely accessible through the Internet. Data storage is provided free by Google Drive fusion tables in a single flat-file type table, periodically downloaded as an offline backup file. Besides the data provided by the users, the software stores accessory data such as primary key of taxa, user id, date and time of data entry, that are used for data analysis. Thanks to the user-friendly interface, data entry is easily accomplished by people with basic computing skills, allowing a quick increase of records stored in the database. Another form is used to query the dataset. The HTML forms connect with the Fusion Tables data and TAXBASE tables through PHP 5.0 scripts. The platform code was written by the senior author (GB).

Data analysis

Sampling density across all Tuscan municipalities was represented by a thematic map, with colour intensity proportional to the number of records located within the territories of each municipality. Municipal boundaries were downloaded from ISTAT (<http://www.istat.it/it/archivio/24613>).

Accepted names were plotted against record number, by random subsampling of the dataset and subsequent count of accepted names in the subsample. Curves (inverse-Harris, Michaelis-Menten) were fitted with nls package of R software (R Development Core Team 2014).

Results

[Wikiplantbase #Toscana](#) has been online since 15 June 2013; its current holdings (updated as of 5 January 2015) are summarised in Table II. They result from the coordinated effort of 19 out of 30 registered users, including several non-academic collaborators. Sampling density across Tuscan territory is heterogeneous (Fig. 3), with four municipalities currently lacking any floristic record: Bucine, Marciano della Chiana, Monte San Savino, Ortignano Raggiolo (all within the province of Arezzo). On the contrary, floristic data are present for all 10 provinces, ranging from 14333 records

for 2162 taxa in the province of Grosseto to 3508 records for 1194 taxa in the province of Prato (data not shown). Most records are based on published data (80.6% of the total), then on published herbarium specimens (15.1%) and so-far unpublished field data (3.8%); unpublished herbarium records account only for 0.5% of the stored data. Figs. 4 and 5 show an example of the output of taxon- and location- based queries. There is a large variation in the number of records species-wise: the fern *Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum* (Dennstaedtiaceae) is represented by 234 records for 219 localities, but 625 species are still represented only by one record for a single locality. According to our subsampling analysis, the number of accepted names is still increasing in a quasi-linear way with the number of records (Fig. 6). The best-fit inverse Harris curve has no upper bound, while second best-fit Michaelis-Menten curve is bound by its asymptote at 3821 taxa.

Discussion

Our results suggest that data acquisition is far from complete – in agreement with the low frequency of unpublished herbarium records – and that the Tuscan flora is expected to exceed the 3541 units reported in Peruzzi (2010; current figure: 3810 taxa, L. Peruzzi and B. Pierini, unpublished data). Presently, about 30% of the data published in the early seminal works of Caruel (1860-1864) and Baroni (1897-1908) were entered in the database, and we seek for a completion during the next one/two years. On the contrary, the insertion of several other important literature sources is already completed, such as Fiori (1943), Marchetti (1992), Chiarucci et al. (1993), Baldini (1998, 2001), Selvi (1998), Mazzeschi and Selvi (1999), Garbari (2001), Angiolini et al. (2002), Biagioli et al. (2002), Selvi and Bettini (2004), Gabellini et al. (2006), Lastrucci and Raffaelli (2006), Venturi (2006), Foggi et al. (2007), Frignani et al. (2004, 2008), Pierini et al. (2009), Mereu et al. (2010), Rizzotto (2010), Peruzzi et al. (2011), Gestri & Peruzzi (2012).

The need of further data is even more evident if the provincial level is considered. For instance, in a recent survey of the vascular flora in the province of Lucca, Pierini and Peruzzi (2014) recorded 2333 taxa. In our dataset, only distributive data for 1746 taxa (ca. 75%) are available for this area. However, for certain taxonomic groups (i.e. lycophytes, ferns and fern allies) we can retain the coverage as nearly complete.

Despite these shortcomings, Wikiplantbase #Toscana is currently the web site with the largest amount of publicly accessible primary biodiversity data for vascular plants in Tuscany. With its >67,000 records, it is still growing rapidly, and is on its way towards the full representativeness of the Tuscan vascular flora.

We speculate that about 300K records are needed to have a nearly complete coverage of the data available in literature, requiring a continuing effort in data entry from users and possibly from batch operations enabled by collaborative agreements with individuals and institutions wishing to share large amounts of data.

Such a massive dataset, updated with relatively little effort as regards data entry, could power several lines of research, such as: 1) taxonomic and floristic studies, especially on species and genera in Tuscany and Italy; 2) studies on the distribution of diversity across administrative or ecological boundaries; 3) evaluation of conservation status of endangered taxa; 4) static and dynamic range modelling and evolution niche studies. Thanks to the localisation on the map, our platform provides an instantaneous geographic pattern at both regional and local scale if desired. This important feature will constantly improve with the continuous input of new records. Furthermore, with minor software tweaking, the online platform [Wikiplantbase #Toscana](#) might be adopted in other contexts, resulting in a well connected network of regional floristic databases suited to exploit the involvement – still largely untapped – of non-academic collaborators, as advocated by citizen science (Cohn 2008, Bonney et al. 2009, Silvertown 2009). As a demonstration of this, during summer 2014, we were contacted by researchers from University of Sassari (Sardinia), interested to replicate our platform for their region. As a result, since 17 November 2014, [Wikiplantbase #Sardinia](#) is available online, with 1020 records available as of 5 January 2014 (Bagella et al. 2014 onwards).

Future developments will a) improve the integration between floristic records and TAXBASE, b) provide a number of geographic query options, such as what and how many species are bound by a polygon (for instance an administrative border or an ecological boundary), by a fixed-radius circle within any point on the map, or by a fixed-size grid, like e.g. the grid used to assess IUCN risk category in the Red List of the Italian Flora (Rossi et al., 2013), and c) support a broader geographic scope of the database. This will require moving the data from the current FusionTables database to a

more powerful, SQL-compliant database engine with support for geographic queries. This transition, enabling a stronger support to floristic, taxonomic, and conservation projects at national level, is already in progress and will be completed by June 2015. Following this upgrade, it will be possible to link the database to the Italian National Biodiversity Network (Martellos et al., 2011).

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TABLE I. Fields of the online entry form to record floristic data into Wikiplantbase #Toscana.

1.record kind (3 fields)	observation; literature; published herbarium specimen; unpublished herbarium specimen	present; doubtful; to be excluded	native; invasive alien; naturalized alien; casual alien; cultivated
2.original name used for the record (3 fields)	Family	Genus	Species/subspecies
3.accepted name (3 fields, automatically filled)	Family	Genus	Species/subspecies
4.record date	day, month, year		
5a.Locality (3 fields)	province	municipality	locality toponym
5b.locality as reported in the original source	copied exactly from the source		
6a.coordinates (WGS84, automatically filled if the toponym is in the database)	decimal degrees		
6b.accuracy	1.low (region or a very large geographical portion of the region) 2.above 50 Km (but still a restricted portion of the region) 3.between 10 and 50 Km 4.between 1 and 10 Km 5.less than 1 Km		
7.habitat (optional, 3 fields)	Corine code L1	Corine code L2-3	free text
8.elevation (optional)	m a.s.l.		
9.herbarium (2 fields)	herbarium acronym (Thiers 2015)	official collector(s)	
10.literature reference (automatically filled if the reference is in the database)	Surname N., Year. Title. Journal volume(issue): initial page-end page.		
11.notes (optional)	free text		
12.additional literature reference (optional)	Surname N., Year. Title. Journal volume(issue): initial page-end page.		

TABLE II. Current holdings stored in Wikiplantbase #Toscana.

N° stored records	67360
N° accepted specific and subspecific taxa	3578
N° genera	994
N° families	154
N° localities	5906
N° literature references	779



Wikiplantbase #Toscana

Editori:
L. Peruzzi, G. Bedini, Università di Pisa



Wikiplantbase #Toscana
verso un catalogo collaborativo, online e gratuito delle piante vascolari di Toscana

67360
segnalazioni archiviate

RICERCA

- [[segnalazioni](#)]
- [[toponimi](#)]*
- [[fonti bibliografiche](#)]*

INSERIMENTO DI DATI

- [[Inserisci nuove segnalazioni](#)]*
- [[Rivedi le tue segnalazioni](#)]*
- [[Non ho i codici di accesso, come faccio?](#)]
- [[Guida all'inserimento di nuove segnalazioni](#)]
- [[Verifica segnalazioni](#)] (riservato ai curatori)

IL PROGETTO

- [[Sommaro](#)]
- [[Statistiche](#)]
- [[Densità delle segnalazioni](#)]

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Trovaci su Facebook



Flora della Toscana
✓ Mi piace Ti piace.

Flora della Toscana piace a te e altre 566 persone.

Plugin sociale di Facebook

Colladato per [Mozilla Firefox](#) e [Google Chrome](#). Citazione suggerita: Peruzzi L., Bedini G (eds), 2013. Wikiplantbase #Toscana v1.0. http://www.biologia.unipi.it/ortobotanico/FloraToscana/flotos_start.html Informazioni [Lorenzo](#)

Peruzzi, Gianni Bedini Ultimo aggiornamento: 23 agosto 2014

Fig. 1. Wikiplantbase #Toscana homepage as of 5 January 2015 (http://www.biologia.unipi.it/ortobotanico/FloraToscana/flotos_start.html).

INSERIMENTO DI NUOVA SCHEDA: inserire i dati e cliccare sul pulsante "Invia" in fondo alla scheda

1. Tipo di reperto: Scegli il tipo!
Inserire il tipo di reperto tramite l'elenco a tendina di sinistra. Se la segnalazione si riferisce a un'esclusione dalla flora, selezionare "esclusione" dall'elenco a tendina di destra.

2. Sub: ***Scegli famiglia ***Scegli specie
Inserire il nome indicato sul quaderno di campagna, sul cartellino d'erbario o nella fonte bibliografica

3. Nome scientifico: ***Scegli famiglia ***Scegli specie
Inserire il nome oggetto di segnalazione secondo la Checklist e successivi aggiornamenti

4. Data del reperto:
Inserire la data di raccolta/osservazione in base al reperto (g/mmm/aaaa, es: 17 Mar 1861; 2 Jun 1946)

5a. Prov., comune, loc.: ***Scegli provincia *** Località
5b. Località precisa:
Inserire provincia, comune tramite l'elenco a tendina e la località nella casella di testo. Eventuali precisazioni sulla località vanno nella seconda riga

6a. Coordinate:
6b. Accuratezza: 1 (Reg) 2 (> 50 km) 3 (> 10 km) 4 (> 1 km) 5 (< 1 km)
Inserire lat e long nel formato decimale, di Google Maps (meglio se con "copia e incolla")

7. Ambiente: ***Cod. Corine L1
Inserire informazioni sull'ambiente di raccolta/osservazione

8. Quota:
Inserire la quota in m sul livello del mare

9. Erbario *** Sigla IH *** Legit
Per i campioni d'erbario inserire la sigla internazionale dell'erbario e il nome dei raccoglitori

10. Fonte bibliografica: *** Fonte bibliografica della segnalazione (per esteso)

11. Note:

12. Bibliografia suppl.: *** Fonti bibliografiche supplementari

Fig. 2. Data entry form. See Table 1 for more information about the fields.

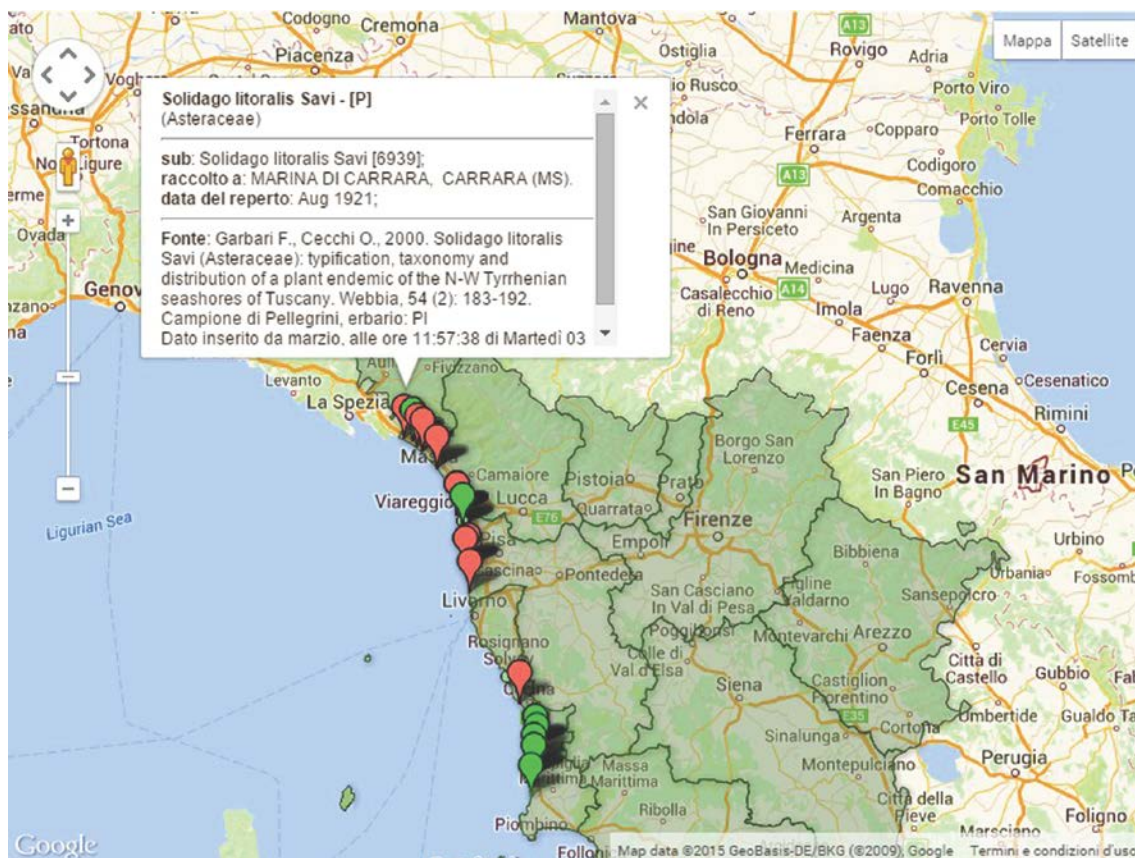


Fig. 4. Map output for a taxon-based query, showing georeferenced records for the narrow endemic *Solidago litoralis* Savi (Asteraceae). Red drop: herbarium/bibliographic record \leq 1950; green drop: herbarium/bibliographic record $>$ 1950. Note the balloon graphic with record data, activated by clicking on the drops. A textual output is also produced, not shown here.

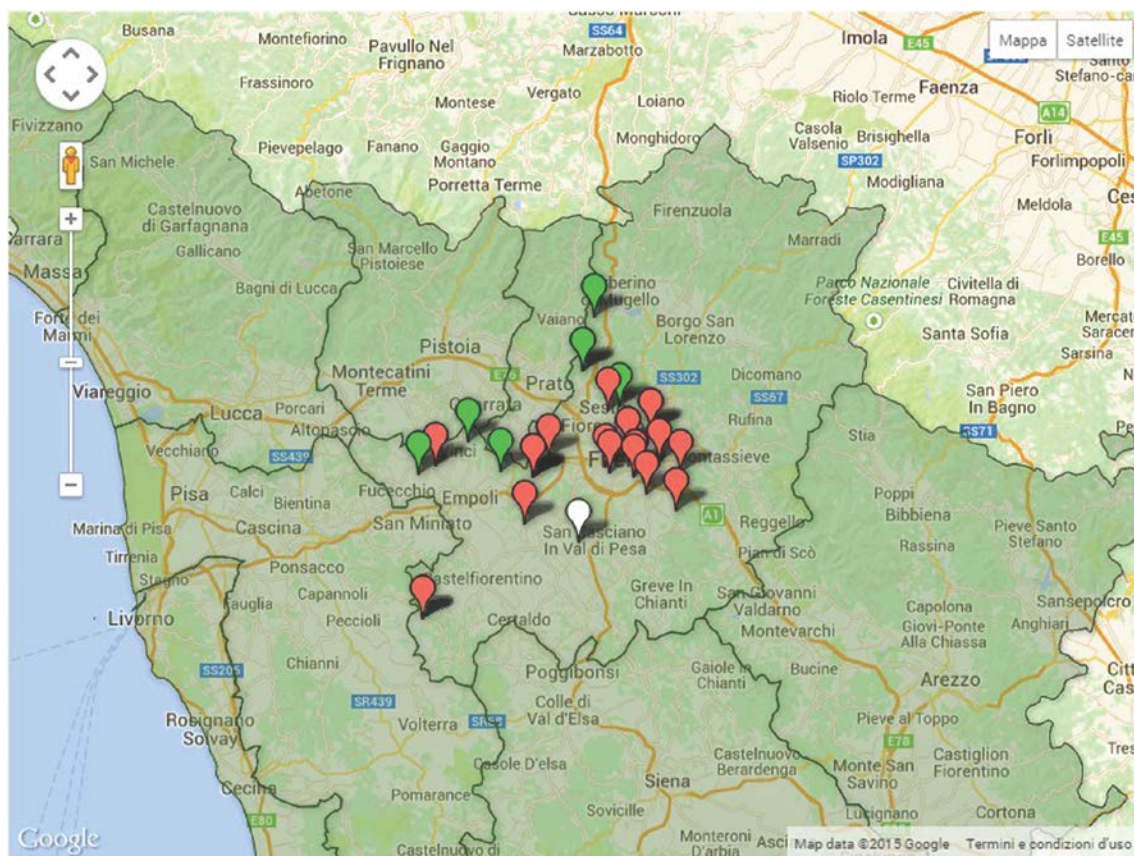


Fig. 5. Map output for a location-based query, showing georeferenced records for species of the genus *Sternbergia* (Amaryllidaceae) in the province of Florence. Red drop: herbarium/bibliographic record ≤ 1950 ; green drop: herbarium/bibliographic record > 1950 ; white drop: herbarium/bibliographic record without date available.

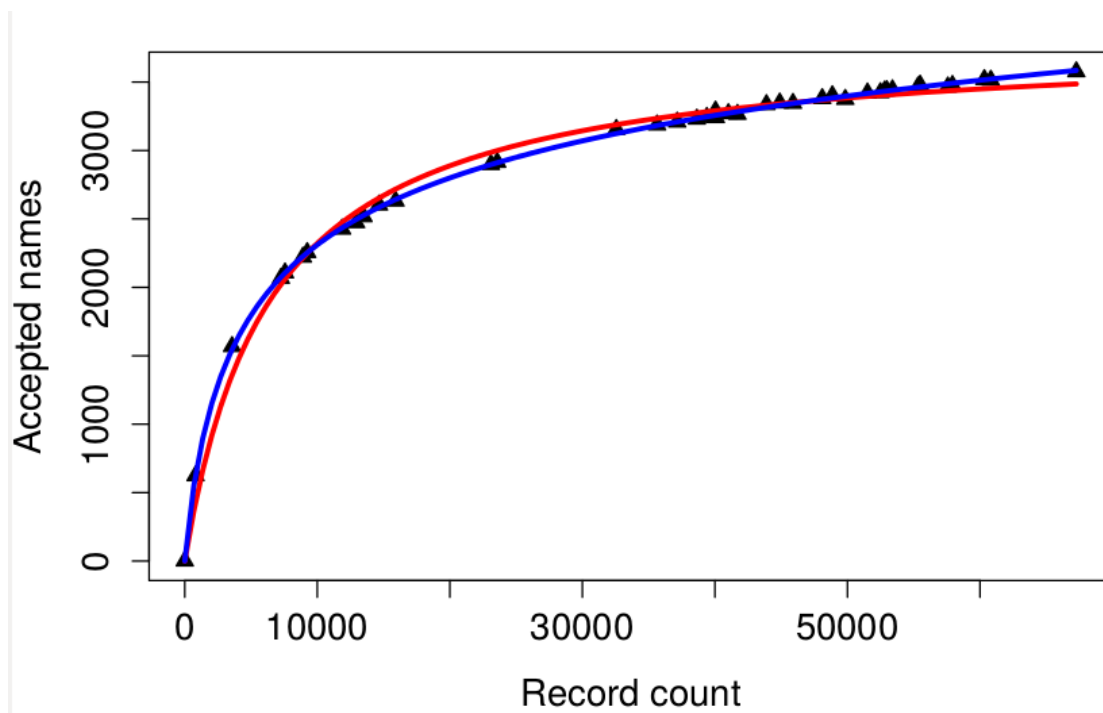


Fig. 6. Plot of accepted names (n) against record number. Triangles: experimental data obtained by random subsampling of the dataset and subsequent count of accepted names in the subsample. Lines: fitted functions, blue = inverse Harris $f(x) = x / (0.9112 + 0.0012 * x^{0.8675}) + 0.4519$ (RSE = 13.85, df = 37), red = Michaelis-Menten $f(x) = 3821.28 * x / (6456.74 + x)$ (RSE = 65.39, df = 39).