

# 1 VectAbundance: a spatio-temporal database of 2 vector observations

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36 **Abstract**

37 Modelling approaches play a crucial role in supporting local public health agencies by  
38 estimating and forecasting vector abundance and seasonality. However, the reliability of  
39 these models is contingent on the availability of standardized, high-quality data. Addressing  
40 this need, our study focuses on collecting and harmonizing egg count observations of *Aedes*  
41 *albopictus*, obtained through ovitraps in monitoring and surveillance efforts across Albania,  
42 France, Italy, and Switzerland from 2010 to 2022. We processed the raw observations to  
43 obtain a continuous time series of ovitraps observations allowing for an extensive  
44 geographical and temporal coverage of *Ae. albopictus* population dynamics. The resulting  
45 post-processed observations are stored in the open-access database VectAbundance,  
46 currently hosting data for *Ae. albopictus*. Future database releases may include  
47 observational data for other medically significant vectors, such as the common house  
48 mosquito *Culex pipiens* or the tick *Ixodes ricinus*. This initiative addresses the critical need  
49 for accessible, high-quality data, enhancing the reliability of modelling efforts and bolstering  
50 public health preparedness.

51

52 **Keywords**

53 invasive mosquito species, time-series, vector-borne disease

54 **Author Contributions**

55 Daniele Da Re, Beniamino Caputo, Alessandra della Torre and Roberto Rosà conceived the  
56 study; Daniele Da Re and Roberto Rosà designed the methodology, with relevant  
57 contributions from Giovanni Marini and Fabrizio Laurini; Nikoleta Anicic, Alessandro Albieri,  
58 Paola Angelini, Carmelo Bonannella, Daniele Arnoldi, Federica Bertola, Beniamino Caputo,  
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62 Zandonai collected the data; Daniele Da Re, Marharyta Blaha, Giovanni Marini, Fabrizio  
63 Laurini, and Roberto Rosà analysed the data; Daniele Da Re led the writing of the  
64 manuscript. All authors contributed critically to the drafts and gave final approval for  
65 publication.

66

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## 79 1. Background

80 The *Aedes* invasive mosquitoes (AIMs) are a group of arthropod vectors that have  
81 attracted the interest of scientists and public health officers because of the recent expansion  
82 of their geographical ranges and their capacity to transmit viruses that affect humans  
83 (Medlock et al., 2015; Ibáñez-Justicia, 2020). Among the different AIMs, the "Asian tiger  
84 mosquito" (*Aedes (Stegomyia) albopictus* (Skuse, 1895) experienced a significant range  
85 expansion in the past three decades and it is still rapidly extending northward and increasing  
86 in altitude, mediated by climate change, thermal adaptation, and the intense transportation of  
87 goods and people (Roche et al., 2015; Ibáñez-Justicia, 2020; Marini et al., 2020; Romiti et  
88 al., 2022). *Aedes albopictus* proved to be a competent vector of several arboviruses,  
89 including dengue, chikungunya, Zika, West Nile, eastern equine encephalitis and La Crosse  
90 viruses (Cancrini et al., 2003; Koch et al., 2016; McKenzie, Wilson and Zohdy 2019; Takken  
91 and van den Berg 2019), having been already responsible for several outbreaks of vector-  
92 borne diseases in Mediterranean Europe (Rezza et al., 2007; Venturi et al., 2017; Brady et  
93 al., 2019; Barzon et al., 2021). Besides, it also acts as a vector of filarial nematodes, such as  
94 *Dirofilaria immitis* and *D. repens* (Cancrini et al., 2003).

95 Given its medical importance, European, national and local guidelines exist to  
96 conduct surveys and surveillance programs to monitor *Ae. albopictus*' local abundance,  
97 population dynamics, and assess the risk of disease transmission (Italian Ministry of Health,  
98 2020; European Centre for Disease Prevention and Control, 2021; PNA). These guidelines  
99 are then locally implemented according to several limiting factors, such as budgeting costs  
100 and extension of the area to monitor (e.g., Jourdain et al., 2019; Di Luca, 2022). Among the  
101 different means for monitoring *Ae. albopictus* populations, ovitraps are cheap and efficient  
102 tools consisting of a dark container filled with water and a substrate where mosquitoes can  
103 lay their eggs. Ovitrap are inspected every one to two weeks by counting the number of  
104 eggs on the substrate to retrieve information on the mosquito phenology and population  
105 dynamic. Ovitrap application for mosquito monitoring and control is widespread (Albieri et  
106 al., 2010; Carrieri et al., 2011; Silva et al., 2018; Bellini et al., 2020; Chaves et al., 2021;  
107 Lencioni et al., 2023) and they are used in conjunction with other mosquito control methods  
108 for comprehensive management strategies (e.g., BG-sentinels).

109 The availability of resources and funds directly affects the sampling strategies and  
110 protocols employed by the different stakeholders (Baldacchino et al., 2017; Guzzetta et al.,  
111 2017): the sole Emilia-Romagna region (Northern Italy, ~ 4,500,000 inhabitants) refunds  
112 municipalities involved in the field monitoring activities ~ 70,000 euro/year (VAT included) to  
113 maintain a regional monitoring system of 755 ovitraps inspected from the end of May (week  
114 21) to beginning of October (week 40) and pays about 20,000 euro/year to the Regional  
115 Agency for Environmental Protection for eggs counting operations (Canali et al. 2017).

116 Resource limitations pose challenges to achieving comprehensive and widespread  
117 monitoring coverage, restricting each monitoring effort's temporal and spatial extent and  
118 producing gaps in data collection in certain geographical areas or during specific periods.  
119 Therefore, the collection and standardisation of these monitoring data are widely advocated  
120 (Jourdain et al., 2019; Bellini et al., 2020; Michaelakis et al., 2021) and crucial to  
121 implementing passive surveillance systems (Caputo and Manica, 2020), i.e. modelling  
122 approaches, that can estimate and forecast the abundance and seasonality of vectors,  
123 providing undeniable support to local public health agencies. In fact, during the past two

124 decades, statistical models have been widely used to infer the geographic distribution and  
125 phenology of *Ae. albopictus* (Lippi et al., 2023). These models have shown to be extremely  
126 useful when predicting mosquito populations/suitability estimates in areas where no  
127 observations are available due to observation paucity (gap-filling). However, the lack of  
128 standardised and accessible high-quality data can hinder the reliability of model estimates  
129 and forecasts (Cayuela et al., 2009). While detailed monitoring in a specific area enhances  
130 precision in model estimates, the broader applicability of these findings may be  
131 compromised. This underscores the crucial significance of having accessible high-quality  
132 data that spans diverse spatial and temporal conditions.

133 In this study, we collected and harmonised *Ae. albopictus* egg count observations  
134 that were sampled using ovitraps during the monitoring and surveillance activities conducted  
135 in four different countries, namely Albania, France, Italy and Switzerland from 2010 to 2022.  
136 We processed the raw observations to obtain a continuous time series of ovitraps  
137 observations allowing for an extensive geographical and temporal coverage of *Ae.*  
138 *albopictus* population dynamics. We stored the post-processed observations in the open-  
139 access database VectAbundance. Contrary to other efforts to collect and standardize vector  
140 data (e.g. Kraemer et al., 2015a; Braks et al., 2022; Uelmen et al., 2023) this dataset is not  
141 based on raw observations, but it proposes post-processed observations ready to be  
142 implemented for modelling applications. Presently, VectAbundance hosts observations for  
143 *Ae. albopictus* only, but future releases of the database might make available observational  
144 data for other vectors of medical interest such as the common house mosquito *Culex*  
145 *pipiens* or the tick *Ixodes ricinus*.

## 146 2. Methods

147 In the context of the AIM-COST COST action (<https://www.aedescost.eu/>), we  
148 contacted stakeholders from four European countries (Albania, France, Italy, and  
149 Switzerland) that had active monitoring and surveillance programs of *Ae. albopictus* utilising  
150 ovitraps between 2010 and 2022. In the following section, the sampling strategies and  
151 protocols employed by the different stakeholders are presented.

### 152 2.1 Sampling strategies

#### 153 2.1.1 Albania

154 The Vector Control Unit, Institute of Public Health in collaboration with Local Health Care  
155 Units in Vlore and Fier, carries out the monitoring activities within the regions of Albania.

##### 156 **Ovitraps characteristics**

157 The ovitraps involved in the mosquito monitoring program from 2014 to  
158 2022 are made of a black plastic cylindrical vessel (9 cm height x 11 cm  
159 diameter; Ramona Ø11/H9, Luwasa® Interhydro AG) with an overflow hole  
160 at 7 cm from the base. Inside the ovitraps, a deposition substrate made of  
161 germination paper (<http://www.anchorpaper.com/index.php/seed-solutions>) is  
162 attached using a clip. The oviposition substrate was changed from germination paper  
163 to a scratched wooden tongue depressor (1.7 × 15 cm) during the surveys of 2020-  
164 2022 in all localities except for 6 ovitraps located in the municipality of Tirana.

##### 165 **Number of ovitraps and length of the monitoring season**

166 The municipalities of Fier and Vlore were monitored using 30 ovitraps, which were  
167 inspected weekly from late May (week 21) to late December (week 51) in 2020 and  
168 from late May (week 21) to early October (week 40) in 2021. The municipality of  
169 Lushnje was monitored biweekly using 10 ovitraps from late August (week 34) to  
170 early October (week 40) in 2020 and from late May (week 21) to late September  
171 (week 38) in 2021. The municipality of Lezhe was monitored in 2021 only, using 5  
172 ovitraps that were inspected every two weeks from early June (week 23) to late  
173 September (week 38). The municipality of Kavaje was monitored in 2021 only, using  
174 5 ovitraps that were inspected every two weeks from early June (week 22) to early  
175 October (week 40). The municipality of Tirana was monitored every week using 35  
176 ovitraps from mid-May (week 20) to late December (week 51) during 2020-2022. The  
177 ovitraps inspected every two weeks were treated with VectoMax® FG based on  
178 *Bacillus thuringiensis* var. *israelensis* and *Bacillus sphaericus*. All ovitraps have been  
179 georeferenced using the WGS84 coordinate system with the EPSG code 4326.

##### 180 **Surveys and reporting**

181 During every survey, the status of each ovitrap is assessed. If an ovitrap is  
182 found dry or overturned, the germination paper or tongue depressor is not  
183 considered, and therefore the value assigned to that ovitrap is NA. The germination  
184  
185  
186

187 paper or tongue depressor collected is delivered to the Institute of Public Health  
188 laboratories to identify and count any eggs using a stereomicroscope.

## 189 2.1.2 France

190 The monitoring activities within the Cote Azur region are carried out by the 'Entente  
191 interdépartementale pour la démoustication du littoral méditerranéen (EIDMediterranée), a  
192 public agency for mosquitoes control in coastal wetlands.

193

### 194 **Ovitrap characteristics**

195 The ovitraps involved in the mosquito monitoring program in Nice municipality  
196 from 2014 to 2019 are made of a black plastic cylindrical vessel (9.5 cm height x 11  
197 cm diameter).

198

### 199 **Number of ovitraps and length of the monitoring season**

200 The municipality of Nice was monitored using 50 ovitraps from late May (week 21) to  
201 early October (week 40) with revisiting time every 14 days. All ovitraps have been  
202 georeferenced using the WGS84 coordinate system with the EPSG code 4326.

203

### 204 **Surveys and reporting**

205 During every survey, the status of each ovitrap is assessed. If an ovitrap is  
206 found dry or overturned, the masonite stick is not considered, and therefore the value  
207 assigned to that ovitrap is NA. The masonite sticks collected are delivered to the  
208 EIDMediterranée laboratories for egg identification and count using a  
209 stereomicroscope.

## 210 2.1.3 Italy

### 211 2.1.3.1 Apulia

212 The monitoring activities within the Bari municipality, the capital city of the Apulia region, are  
213 carried out by the University of Bari.

214

#### 215 **Ovitrap characteristics**

216 The ovitraps involved in the mosquito monitoring program are black plastic cups (12  
217 cm height x 8 cm diameter) with a volume of 300 ml filled with 225 ml of tap water  
218 and equipped with a masonite stick.

219

#### 220 **Number of ovitraps and the length of the monitoring season**

221 The monitoring activities for *Ae. albopictus* in Bari municipality began in 2017 and  
222 were conducted sporadically until 2022. Sixty-six ovitraps were placed in the  
223 municipality over 22 sites. The monitoring activities spanned from late April (week 13)  
224 to early December (week 51) with a revisiting time every 7-10 days. All the ovitraps  
225 are georeferenced in the WGS84 coordinate system EPSG:4326.

226

#### 227 **Surveys and reporting**

228 During every survey, the status of each ovitrap is assessed. If an ovitrap is  
229 found dry or overturned, the masonite stick is not considered, and therefore the value  
230 assigned to that ovitrap is NA. The masonite sticks collected are delivered to the  
231 laboratory of parasitology of the University to identify and count any eggs using a  
232 stereomicroscope.

233

### 234 2.1.3.2 Autonomous Province of Trento

235 Within the Autonomous Province of Trento (Northeast Italy), two local stakeholders are  
236 involved in the monitoring activities of *Ae. albopictus*: the Fondazione Museo Civico di  
237 Rovereto surveys mostly the southern part of the Province, mostly the municipality near  
238 Lake Garda, whilst MUSE surveys the city of Trento and its surroundings.

239 Fondazione Museo Civico di Rovereto

#### 240 **Ovitrap characteristics**

241 The ovitraps involved in the mosquito monitoring program from 2010 to 2023  
242 are made of polypropylene (9.5 cm height x 11 cm diameter).

243

#### 244 **Number of ovitraps and length of the monitoring season**

245 The number of municipalities and ovitraps employed in the Ledro e Val  
246 Lagarina areas (southern part of the Autonomous Province of Trento) was not  
247 consistent over the period 2010-2023 and varied largely every year. However, the  
248 ovitraps were always monitored from late May (week 21) to early October (week 40)  
249 with revisiting time every 14 days. All ovitraps have been georeferenced in the ETRS  
250 1989 UTM Zone 32N coordinate system.



251 **Surveys and reporting**

252 During every survey, the status of each ovitrap is assessed. If an ovitrap is  
253 found dry or overturned, the masonite stick is not considered, and therefore the value  
254 assigned to that ovitrap is NA. The masonite sticks collected are delivered to the  
255 MCR laboratories to identify and count any eggs using a stereomicroscope.

256 MUSE

257 **Ovitrap characteristics**

258 The ovitrap employed in the monitoring activities from 2010 to 2023 is a  
259 small black plastic container (12 cm height x 8 cm diameter, volume 400 ml) with a  
260 hole two centimetres from the edge to prevent overflowing, mimicking the preferred  
261 natural and artificial breeding sites for the species, i.e., tree-holes, rock-holes and  
262 small man-made containers. The container is filled for two-thirds with water and  
263 contains a wood or masonite rough paddle (3 cm width x 13 cm length x 0.3 cm  
264 thickness) for adult females to lay eggs on. Until 2016, diflubenzuron® 2% was  
265 added to water in each trap, but in 2017 it was replaced with the microbiological  
266 larvicide (VectoMax® FG) based on *Bacillus thuringiensis* var. *israelensis* and  
267 *Bacillus sphaericus* in granular form in dechlorinated water at a concentration of 1  
268 ml/litre.

269  
270 **Number of ovitraps and length of the monitoring season**

271 The municipality of Trento is monitored using 84 ovitraps from late May (week  
272 21) to early October (week 40) with revisiting time every 14 days. All ovitraps have  
273 been georeferenced in the ETRS 1989 UTM Zone 32N coordinate system. Data  
274 included in this work refers to 22 traps for which long-term data are available (2010-  
275 2023).

276  
277 **Surveys and reporting**

278 During every survey, the status of each ovitrap is assessed. If an ovitrap is  
279 found dry or overturned, the masonite stick is not considered, and therefore the value  
280 assigned to that ovitrap is NA. The masonite sticks collected are delivered to the  
281 MUSE laboratories to identify and count any eggs using a stereomicroscope. The  
282 confirmation of *Ae. albopictus* identification was done by rearing eggs caught with  
283 extra masonite sticks in traps without the insecticide and with the adult collection  
284 employing BG-Sentinel traps in the same locations.

285 2.1.3.3 Emilia-Romagna

286 The monitoring activities within the Emilia-Romagna region are coordinated by the Local and  
287 Regional Public Health departments and are carried out operatively by the municipalities  
288 involved (Carrieri et al. 2011).

289  
290 **Ovitrap characteristics**

291 The ovitraps involved in the mosquito monitoring program from 2010 to 2022  
292 are made of cylindrical plastic jars, black in colour, with a volume of 1.4 litres and a  
293 diameter of 11 cm (CAA14GG/CAA14G model). They are perforated at  
294 approximately 2/3 of their height to contain about 800-900 ml of solution. The used  
295 ovitraps are filled with a solution of B.t.i. (*Bacillus thuringiensis israelensis* - 1,200  
296 UTI/mg) in dechlorinated water at a concentration of 1 ml/litre. Inside them, a

297 deposition substrate is attached using a clip or a wooden clamp, which consists of a  
298 masonite stick (2.5 cm width x 14.5 cm length) with the rough side exposed to the  
299 water.

300 The ovitraps are covered by a plastic mesh with a 1 cm-sized opening, fixed  
301 along the edge to prevent contact between the solution and domestic animals,  
302 thereby reducing the risk of overturning. Additionally, the mesh prevents the  
303 accumulation of leaves or other debris inside the ovitraps, which, if allowed to  
304 ferment, could interfere with their attractiveness. As a result, the deposition  
305 substrates remain cleaner, making classification and counting easier.

306

#### 307 **Number of ovitraps and length of the monitoring season**

308 Ten municipalities are monitored using 755 ovitraps from late May (week 21)  
309 to early October (week 40) with revisiting time every 14 days. All ovitraps have been  
310 georeferenced in the ETRS 1989 UTM Zone 32N coordinate system.

311

#### 312 **Surveys and reporting**

313 During every survey, the status of each ovitrap is assessed (Regional  
314 Surveillance Operative protocol; Di Luca, 2022). If an ovitrap is found dry or  
315 overturned, the masonite stick is not considered, and therefore the value assigned to  
316 that ovitrap is NA. The masonite sticks collected are delivered to the Regional  
317 Environmental Agency (ARPAE) laboratories to identify and count any eggs using a  
318 stereomicroscope. A quality check is then performed on the egg count data following  
319 the protocol described in Carrieri et al 2017, and, if they pass the quality check, are  
320 published on the regional portal [www.zanzaratigreonline.it](http://www.zanzaratigreonline.it).

#### 321 2.1.3.4 Lazio and Tuscany

322 The Istituto Zooprofilattico Sperimentale del Lazio e della Toscana (IZSLT) is responsible for  
323 monitoring activities within the Lazio and Tuscany regions.

324

#### 325 **Ovitraps characteristics**

326 The ovitraps involved in the mosquito monitoring program from 2017 to 2023  
327 consisted of a 400 ml black plastic container filled with 300 ml tap water and  
328 equipped with a masonite stick (3 cm width x 15 cm length) for oviposition. The  
329 oviposition substrate was diagonally positioned with the rough side towards the  
330 centre of the container. The ovitraps were placed outdoors, at ground level, in  
331 sheltered and shaded places, and were left in the same position throughout the  
332 whole monitoring period. The ovitraps were set in urban areas, within public or house  
333 gardens, hospitals or seats of the local health service, gathering places (e.g.  
334 markets, train stations and churches), graveyards and container terminals.

335

#### 336 **Number of ovitraps and length of the monitoring season**

337 The number of ovitraps employed in the Lazio and Tuscany regions varied  
338 considerably across 2017-2022. In the Lazio region, in 2017 there were 5 active  
339 ovitraps, which increased to 59 in 2018, 81 in 2019, 75 in 2020, 80 in 2021, and 85 in  
340 2022. In the Tuscany region, the monitoring activities started in 2020 with 21 active  
341 ovitraps, which increased to 26 in 2021, and 69 in 2022. The ovitraps were monitored  
342 from late May (week 21) to early October (week 40), with revisiting time every 7 days.  
343 From early October to late May of the following year, the revising time passed to 14

344 days. All ovitraps have been georeferenced in the ETRS 1989 UTM Zone 32N  
345 coordinate system.

346

### 347 **Surveys and reporting**

348 During every survey, the status of each ovitrap was assessed (Romiti et al.,  
349 2021). If an ovitrap was found dry or overturned, the masonite stick was not  
350 considered and therefore the value assigned to that ovitrap was NA. The collected  
351 masonite sticks were delivered to the IZSLT laboratory for egg identification and  
352 count. Eggs were counted under a stereomicroscope. To confirm *Ae. albopictus*  
353 identification, randomly chosen masonite sticks from each site were put in water with  
354 a source of food to allow egg hatching and larval development in adults. Adult  
355 mosquitoes were morphologically identified using the identification keys of Severini et  
356 al. (2009) and Ree (2003).

### 357 2.1.3.5 Sicily

358 The monitoring activities within the Sicily region are carried out by the Istituto Zooprofilattico  
359 Sperimentale della Sicilia at the laboratory of “Entomologia e controllo dei Vettori Ambientali”  
360 (EVA).

361

### 362 **Ovitraps characteristics**

363 The mosquito monitoring program spanned from January 2010 to January  
364 2018. A second surveillance activity started in May 2021 and lasted until August  
365 2022. The ovitraps employed consist of a black polypropylene cup with a capacity of  
366 500 ml. An oviposition substrate consisting of a stick of masonite (2.5 cm width x 30  
367 cm length x 0.3 cm thickness) is dipped into the water (no support is used, the stick  
368 is made of material rigid enough to self-support itself)

369

### 370 **Number of ovitraps and length of the monitoring season**

371 Five ovitraps are placed within the area of the Istituto Zooprofilattico  
372 Sperimentale della Sicilia “A. Mirri”. The ovitraps are checked with revisiting time  
373 every 7 days. All ovitraps have been georeferenced in the ETRS 1989 UTM Zone  
374 32N coordinate system.

375

### 376 **Surveys and reporting**

377 During every survey, the status of each ovitrap is assessed. If an ovitrap is  
378 found dry or overturned, the masonite stick is not considered, and therefore the value  
379 assigned to that ovitrap is NA. The masonite stick is delivered to the EVA  
380 laboratories to identify and count any eggs using a stereomicroscope.

### 381 2.1.3.6 Veneto

382 The monitoring activities within the Veneto region are coordinated by the Istituto  
383 Zooprofilattico Sperimentale delle Venezie (IZSVe) and operatively carried out by  
384 municipalities and Local Public Health departments.

385

#### 386 **Ovitrap characteristics**

387 The ovitraps used in the mosquito monitoring programs consisted of a 400 ml  
388 black plastic container filled with 300 ml tap water and equipped with a masonite stick  
389 (3 cm width x 15 cm length) for oviposition. The ovitraps were positioned outdoors, at  
390 ground level, in sheltered and shaded areas, and they remained in the same location  
391 for the duration of the monitoring period, similar to what was previously reported for  
392 Tuscany and Lazio regions. The urban settings for the ovitraps included graveyards,  
393 container terminals, hospitals, public or residential gardens, local health service  
394 offices, and gathering places including churches, rail stations, and marketplaces.

395

#### 396 **Number of ovitraps and the length of the monitoring season**

397 The number of ovitraps employed in the Veneto region varied over the years  
398 and locations according to specific surveillance plans. In the alpine area of the  
399 region, 40 ovitraps were deployed in two municipalities (Feltre and Belluno)  
400 monitored from mid-June to the end of October during 2017-2022. Other  
401 municipalities in the alpine area were monitored using three ovitraps for each  
402 municipality from mid-May to mid-October during 2017-2022. The masonite sticks  
403 were collected every two weeks. Larvicide was not applied because the larval  
404 development time in the alpine area is longer than one week due to lower  
405 temperatures.

406 In the continental area of the region, the Venice and Treviso airports and the  
407 commercial port of Venice were monitored from 2018 to 2022 using seven ovitraps  
408 each from mid-June to the end of October as part of the monitoring of points of entry  
409 of invasive species. The other municipalities in the continental area of the region  
410 were not monitored consistently but only for one or two years. A larvicide (*Bacillus*  
411 *thuringiensis israelensis* - 1,200 UTI/mg) was added to the water in ovitraps at a  
412 concentration of 1 ml/litre; the samples (masonite sticks) were collected every two  
413 weeks except in Occhiobello where no larvicide was used and sticks were collected  
414 weekly. All ovitraps have been georeferenced in the ETRS 1989 UTM Zone 32N  
415 coordinate system.

416

#### 417 **Surveys and reporting**

418 For all samplings, the status of each ovitrap was assessed. If an ovitrap is found dry  
419 or overturned or the masonite sticks are missing, NA is assigned. The collected  
420 masonite sticks were delivered to the IZSVe laboratory for egg identification and  
421 count under a stereomicroscope. In areas where the occurrence of different invasive  
422 *Aedes* species is known, randomly chosen masonite sticks from each site were put in  
423 water with a source of food to allow egg hatching and larval development. Larvae  
424 were morphologically identified using the identification keys of Severini et al. (2009)  
425 and Montarsi et al. (2013).

426

## 427 2.1.4 Switzerland

428 The monitoring activities within the Canton of Ticino region are carried out by the Vector  
429 Ecology unit/group (SUPSI-IM-ECOVET) of the Institute of Microbiology of SUPSI. SUPSI-  
430 IM-ECOVET closely collaborates with cantonal and municipal authorities for active  
431 surveillance.

432

### 433 **Ovitrap characteristics**

434 For the mosquito monitoring program from 2020 to 2022, the ovitraps  
435 consisted of a black plastic container with a volume of 1.5 litres (Ramona  
436 Ø13/H12, Luwasa® Interhydro AG) and a wooden steamed beechwood  
437 (2.5 cm width x 20 cm length x 0.5 cm thick) which function as an  
438 oviposition substrate. Containers are filled with tap water and a few grains  
439 of B.t.i. (*Bacillus thuringiensis israelensis*, Vectobac G®) is added to prevent the  
440 trap from becoming a breeding site (Flacio et al. 2015).

441

### 442 **Number of ovitraps and length of the monitoring season**

443 Four municipalities are monitored using 71 ovitraps from late May (week 21)  
444 to mid-September (week 37). Samples are collected every two weeks by municipality  
445 workers. Swiss national coordinates LV95 and WGS84 coordinate systems are used  
446 as georeference for all ovitraps.

447

### 448 **Surveys and reporting**

449 For all nine samplings, the status of each ovitrap is assessed. If an ovitrap is  
450 found dry or overturned, the substrate is considered altered and eggs are counted. In  
451 case the substrate is missing, NA is assigned. The wooden slats are collected by  
452 municipality workers and are delivered to the SUPSI-IM-ECOVET laboratory to  
453 identify and count Aedine eggs using a stereomicroscope (magnification 50x).

## 454 2.2 Data analysis

455 As described above, each stakeholder, i.e. public health agency or research centre,  
456 adopts different monitoring schemes (i.e., size of the ovitraps, number of ovitraps, length of  
457 the monitoring period, length of the ovitrap activation period, etc.), depending on their needs,  
458 budget, and personnel. As a result, between (but also within) European countries the  
459 monitoring schemes are highly heterogeneous (Jourdain et al., 2019; Miranda et al., 2022),  
460 restricting the temporal and spatial extent of each monitoring effort and producing gaps in  
461 data collection in certain geographical areas or during specific periods. Whilst this is  
462 undoubtedly problematic, some studies suggest that different ovitraps can yield comparable  
463 results in terms of collected eggs (i.e., Velo et al., 2016). To account for this heterogeneity,  
464 we adopted some rules to standardise the different observations. Ovitrap were generally  
465 inspected on a weekly or biweekly basis, depending on the local protocol adopted by the  
466 stakeholders. We chose the week as the fundamental temporal unit of our study, therefore, if  
467 the monitoring period was longer than one week, we performed a temporal downscaling by  
468 randomly distributing the observed egg counts throughout the trap activity period using a  
469 binomial draw with a probability equal to 1/n weeks of activation. This means that if a trap  
470 was active for 2 weeks and a total of 500 eggs were collected, the observed 500 eggs would

471 be randomly assigned to each week with a probability  $p=1/2$ , resulting in, e.g. 256 eggs  
472 collected during the 1st week and 244 collected during the second.

473 For most of the monitored ovitraps, the monitoring period spans from May (week 20) to  
474 October (week 40). Though there is some variability in the length of the monitoring period  
475 depending on the stakeholders' resources and local protocols, the beginning and end of the  
476 monitoring year (from March to May, and from October to February in Europe) are often  
477 characterised by few or no observations. To handle missing or incomplete data and ensure  
478 consistency in analysing ovitrap egg counts throughout the years, we modified the observed  
479 data according to the following assumptions:

- 480 1. For November, December, January and February, if no observation data was  
481 provided, the egg count was assumed to be zero. However, if observations were  
482 available, the weekly number of eggs was calculated as the average of the  
483 observations for each month.
- 484 2. For March and April, if no observation data was provided, the egg count was marked  
485 as "NA," indicating missing or unavailable data, because under warm temperature  
486 conditions, egg hatching might already occur from March (Petric et al., 2021).

487  
488 We coded these rules into the `spreader` R function, which is available in the R package  
489 `dynamAedes` (Da Re et al., 2022) v2.2.8. To reduce variability and to standardise the  
490 sampling effort in the observed egg count over the whole area of interest, we aggregated the  
491 ovitraps within 9x9 km grid cells by calculating median values. Aggregating the data in this  
492 manner allowed for a more comprehensive analysis while mitigating the impact of small-  
493 scale fluctuations in the observed egg counts. The spatial resolution choice is consistent with  
494 the current resolution of the ERA5Land climatic datasets (Muñoz-Sabater et al., 2021), thus  
495 allowing for a potential homogenization between the different datasets and eventually for  
496 modelling analysis.

### 497 3. Data Records

498 We collected data from 2620 ovitraps in four European countries (Albania, France,  
499 Italy and Switzerland). After the aggregation at 9x9 km spatial resolution, we obtained 149  
500 aggregated ovitraps stations belonging to five Albanian NUTS2 administrative levels (Fier,  
501 Lezhe, Lushnje, Tirane, Vlore), seven Italian NUTS2 (Autonomous Province of Trento,  
502 Emilia-Romagna, Puglia, Lazio, Toscana, Sicily, Veneto), one Swiss (Canton of Ticino) and  
503 one French (Côte Azur) (Tab. 1, Fig. 1). Most of the observations were collected during  
504 2020-2022. Still, some NUTS2 units have a long-lasting experience of *Ae. albopictus*  
505 monitoring from 2010 (e.g. Autonomous Province of Trento and Emilia-Romagna region in  
506 Italy and Canton of Ticino in Switzerland).

507 The impact of post-processing, specifically the temporal downscaling, is illustrated in  
508 Fig. 2 for a typical ovitrap across two seasons. The general seasonal pattern remains  
509 consistent, but the observed values are now distributed throughout the ovitrap's activity  
510 period, resulting in a continuous representation of vector seasonality. Additionally, the gaps  
511 at the beginning and end of the years are filled with zeros. If there were no observations  
512 available for the May-April period, which may have low *Ae. albopictus* activity (Petric et al.,  
513 2021; Romiti et al., 2022; Carrieri et al., 2023; Lencioni et al., 2023), those periods are  
514 marked as NA (not available).

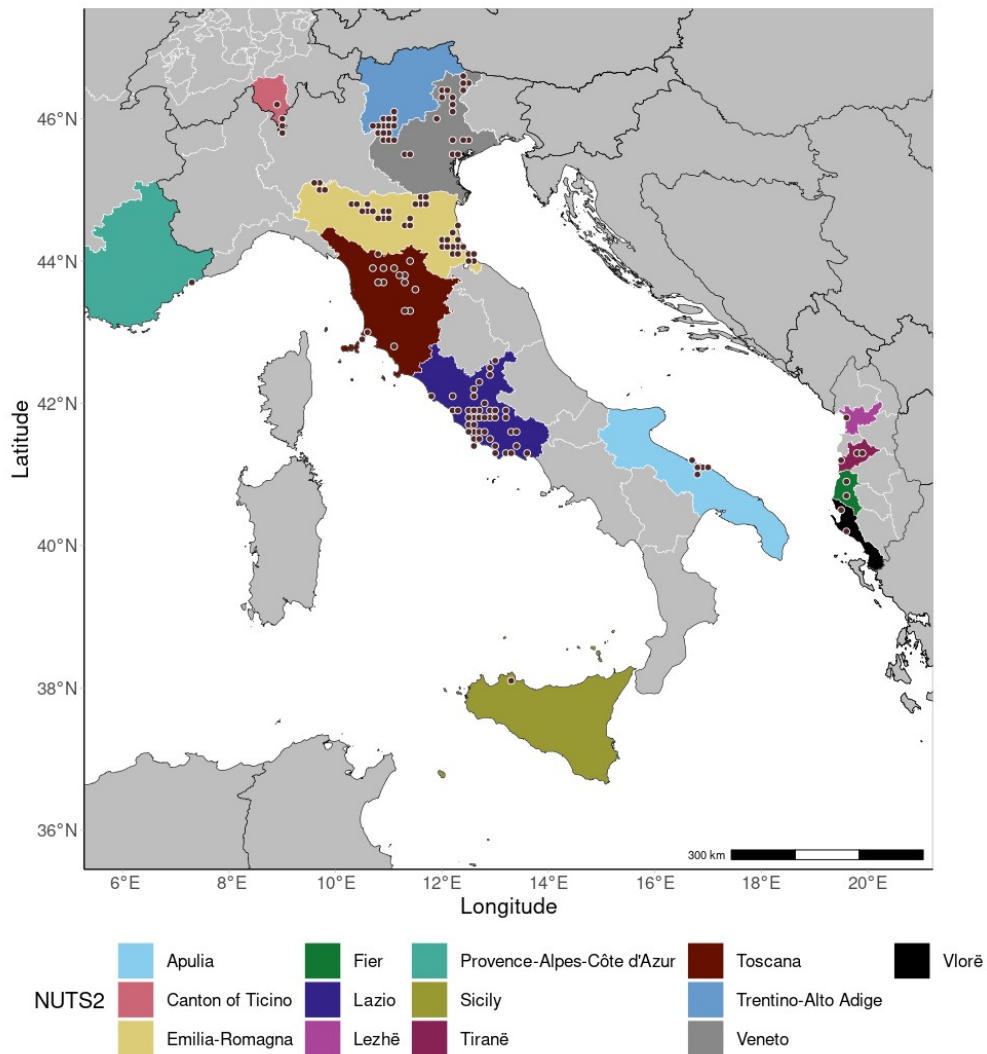
515 The processed database encompasses several descriptive fields. Among them,  
516 "Canonical\_name," "kingdom," "phylum," "class," "order," "family," "genus," and "species"

517 provide taxonomic information about the biological observations. The "life\_stage" field  
 518 specifies the life history stage of the observed species, such as eggs, larvae, pupae, or  
 519 adults. "sampling\_date" notes the date of trap inspection, with the count of individuals stored  
 520 in the "value" field. Additional fields describe trap typology, including "trap\_type," and trap  
 521 characteristics, such as "dimension", "substrate" and "larvicide\_presence". Geographical  
 522 data, including coordinates "lat" and "long" expressed in EPSG:4326, "country", and, "region"  
 523 are also included. Furthermore, there is information about the "institution" responsible for  
 524 monitoring and a designated "contact\_person".

525  
 526  
 527

**Tab. 1** Some summary stats of the ovitraps. Numbers within brackets indicate the total number of deployed ovitraps.

Country	NUTS2	N. aggregated locations	Monitoring period	Biogeographical region
Albania	Fier	1 (n = 10)	2020-2021	Mediterranean
Albania	Lezhe	1 (n = 5)	2021-2021	Mediterranean
Albania	Lushnje	1 (n = 10)	2020-2021	Mediterranean
Albania	Tirane	4 (n = 66)	2014-2022	Mediterranean
Albania	Vlore	2 (n = 20)	2020-2021	Mediterranean
France	Cote Azur	1 (n = 50)	2014-2019	Mediterranean
Italy	Autonomous Province of Trento	15 (n = 464)	2010-2022	Alpine
Italy	Emilia-Romagna	39 (n = 1451)	2010-2022	Continental
Italy	Lazio	42 (n = 162)	2017-2021	Mediterranean
Italy	Puglia	5 (n = 81)	2012-2022	Mediterranean
Italy	Sicily	1 (n = 29)	2021-2022	Mediterranean
Italy	Tuscany	2 (n = 6)	2020-2022	Continental
Italy	Tuscany	14 (n = 71)	2020-2022	Mediterranean
Italy	Veneto	11 (n = 76)	2018-2022	Alpine
Italy	Veneto	8 (n = 79)	2018-2022	Continental
Switzerland	Canton of Ticino	4 (n = 71)	2010-2022	Alpine

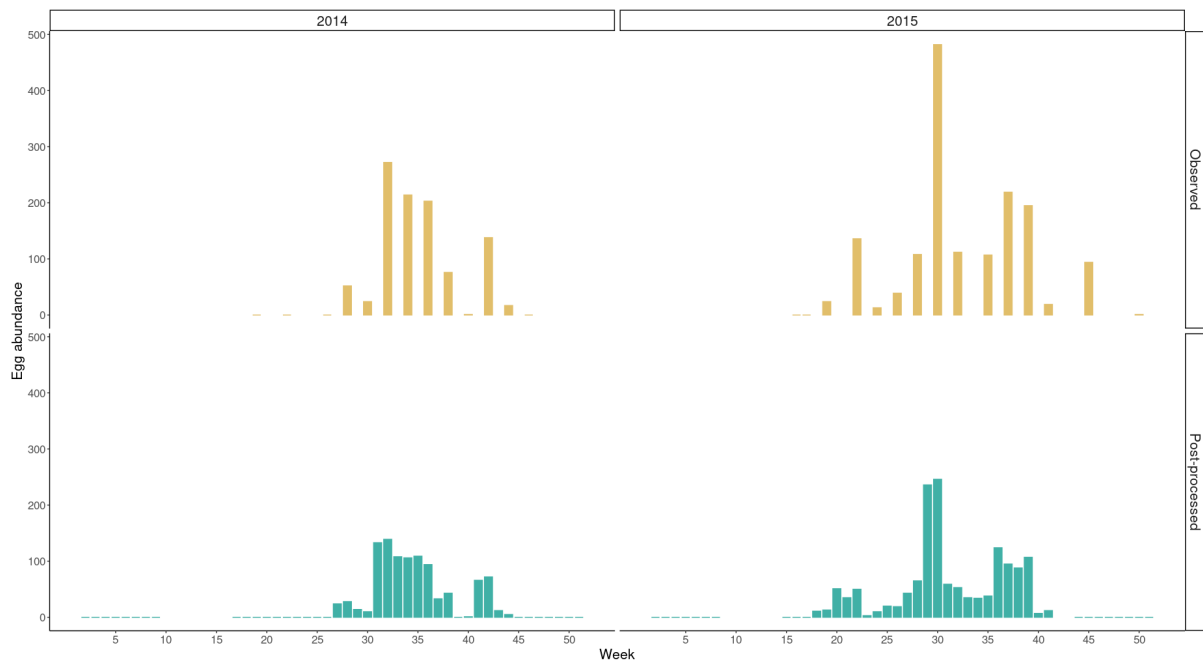


528

529 **Fig. 1** Location (brown dots) of the aggregated ovitraps at 9x9 km spatial resolution. The  
 530 dark grey polygons represent the administrative areas of the countries of interest at the  
 531 NUTS2 level.



532  
533



534  
535 **Fig. 2** Effect of the temporal downscaling on the observed egg counts of a typical ovitrap  
536 across two sampling seasons. The general seasonal pattern remains consistent, but the  
537 observed values are now distributed throughout the ovitrap's activity period.

#### 538 4. Technical validation

539 The ovitraps were surveyed and the eggs were analysed under the stereomicroscope  
540 by trained medical entomologists with more than 20 years of experience in the field. To  
541 confirm *Ae. albopictus* identification, most laboratories randomly reared some of the eggs  
542 collected using the ovitraps and morphologically identified the larvae or the emerged adults.  
543 All the raw observations were already used to perform other analyses and publications (e.g.  
544 Tran et al., 2013; Tisseuil et al., 2018; Romiti et al., 2021; 2022; Da Re et al., 2022; Lencioni  
545 et al., 2023, Ravasi et al., 2021; 2023;), and the observations collected from 65 ovitraps over  
546 6 municipalities in Albania during 2020-2022 were already made available in Miranda et al.  
547 (2022). The procedure of temporal downscaling and spatial aggregation did not alter the  
548 observed seasonal pattern of *Ae. albopictus* egg abundance (Fig. 2). Moreover, the  
549 observed seasonal pattern well matched those reported in other studies (e.g. Guzzetta et al.,  
550 2016; Romiti et al., 2022; Carrieri et al., 2023; Torina et al., 2023) or predicted by different  
551 modelling approaches (e.g. Tisseuil et al., 2018; Ravasi et al., 2022).

#### 552 Data gaps and future developments

553 There is significant scope to further improve VectAbundance's spatial and temporal  
554 coverage on *Ae. albopictus*, as well as including observations on other AIMS species (e.g.  
555 *Ae. aegypti*, *Ae. koreicus*, and *Ae. japonicus*) or other blood-sucking arthropods of medical  
556 interest such as the common house mosquito *Culex pipiens* or the tick *Ixodes ricinus*.

## 557 5. Usage notes

558 VectAbundance presently provides high-quality spatio-temporal observation of *Ae.*  
559 *albopictus* egg abundance data for scientists, researchers, policymakers, and public health  
560 agencies. The data contained in this database are intended to be used to keep track of  
561 current, past and future records of *Ae. albopictus* presence and eggs abundance. Moreover,  
562 the database represents one of the largest openly accessible *Ae. albopictus* data sources  
563 over Europe and can be put into use for several research investigations. VectAbundance  
564 could be exploited to train and/or validate quantitative models at different geographical and  
565 temporal resolutions. Such models could be used to estimate mosquito population dynamics  
566 and abundance (e.g. Kraemer et al., 2015b, 2019; Erguler et al., 2016; Da Re et al., 2022;  
567 Da Re et al., 2023) but also to assess the transmission risk of different Aedes-borne  
568 pathogens (e.g. Guzzetta et al., 2016; Marini et al., 2018). Despite there being few  
569 requirements for contributing data, the database could help set a reference standard for  
570 harmonising and sharing data across different countries in Europe.

## 571 6. Code availability

572 VectAbundance adheres to the FAIR principles (Wilkinson et al., 2016) and is permanently  
573 available in a Zedono repository at [https://XXXXX\(UPON PUBLICATION the database will  
574 be stored in ZENODO\)](https://XXXXX(UPON PUBLICATION the database will be stored in ZENODO)). The code to perform the temporal downscaling is available on the  
575 CRAN at dynamAedes v2.2.8 and a tutorial illustrating how to apply the methodology is  
576 available in the article section of the package's website  
577 <https://mattmar.github.io/dynamAedes/>. The ovitraps raw observations of a specific  
578 stakeholder are available upon request to the contact person shown in the dataset.  
579

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