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This is the author's manuscript

Original Citation:

Availability:

This version is available <http://hdl.handle.net/2318/1630340> since 2018-10-30T10:24:16Z

Published version:

DOI:10.1016/j.agee.2017.03.013

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UNIVERSITÀ DEGLI STUDI DI TORINO

This is an author version of the contribution published on:

Questa è la versione dell'autore dell'opera:

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Agriculture, Ecosystems & Environment, 2017 - 243, 67–73.
<https://doi.org/10.1016/j.agee.2017.03.013>

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**Management systems may affect the feeding ecology of great tits
Parus major nesting in vineyards**

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34 **Abstract**

35

36 The current intensification of agriculture is leading to growing concern about the sustainability
37 of modern farming systems, since farmland biodiversity has severely declined. While several
38 studies have shown that vineyard management systems (i.e. organic vs. conventional) are
39 important factors determining biodiversity and influencing population trends, there is a paucity
40 of studies focusing on the effects at finer levels, such as breeding behaviour, habitat selection
41 and movements. Here, we examined the effects of vineyard management systems on the
42 breeding ecology of great tits (*Parus major*) in north-western Italy. We used nest-boxes to
43 video-record feeding efforts of parents, and radio-telemetry to detect the movements of the
44 males. Habitat composition between the two management systems differed. Organic vineyards
45 were characterized by a high grass cover and the presence of fruit trees, while the presence of
46 bare ground and the use of herbicides were typical for conventional vineyards. The number of
47 nestlings fed by parents per visit and the weight of nine day old nestlings were significantly
48 higher in organic than in conventional vineyards. The diet of nestlings was unaffected by the
49 management system, but depended on the landscape characteristics. Caterpillars were the
50 favourite prey in forest-dominated areas, whereas other invertebrates increased in vineyard-
51 dominated areas. Feeding home range was also independent of the management system, but
52 depended on the age of males (larger in adults). Habitat selection of feeding parents within
53 home ranges was non-random in relation to habitat availability and changed according to the
54 distance from the nest: parents selected forests when they moved far from the nest and used
55 vineyards when remaining in the surroundings of the nest-box. Our results suggest that
56 management systems may affect parental feeding ecology of great tits nesting in vineyards.
57 Differences in the number of nestlings fed per visit and in the weight of the nestlings suggest
58 that conventional vineyards offer fewer feeding resources (and/or of lower quality) than organic
59 vineyards, with potential negative effects on survival of juveniles.

60 **Keywords**

61 Conventional and organic vineyards, video-recording, radio-tracking, home range, diet,
62 landscape, habitat selection, great tit, *Parus major*

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91 **1. Introduction**

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93 The expansion of agricultural land is widely recognized as one of the most significant anthropic
94 environmental changes. The overall surface of cultivated land worldwide increased by 466%
95 from 1700 to 1980 (Meyer & Turner, 1992). While the rate of expansion has slowed over the
96 past three decades, the yield (i.e. the amount of food produced per unit area of cultivated land)
97 has increased dramatically (Naylor, 1996), which has also been supported by economic and
98 technological incentives to increase productivity. Agroecosystems are sustained by diverse
99 inputs, such as human labour and petrochemical energy and products, which replace and
100 supplement the functioning of many ecosystems. The current intensification of agriculture is
101 leading to growing concern about the sustainability of farming systems, since farmland
102 biodiversity has declined severely (Kleijn et al., 2011; Vickery et al., 2004; Woodcock et al
103 2013). This is particularly important because modern agriculture has resulted in a loss of
104 diversity (Aue et al. 2014) due to the homogenization in terms of crops grown and the increase
105 of the yield per area on both animal (Donald et al., 2006; Vickery et al., 2004; Fuller et al.,
106 2005; Mc Donald et al., 2012; Assandri et al., 2017) and plant diversity (Buhk et al., 2017).
107 There is evidence that 19 out of 46 farmland bird species significantly declined throughout
108 Europe as a consequence of agricultural practices and intensification (Donald et al., 2006).
109 Organic farming systems are believed to have less environmental impact than conventional
110 intensive agriculture, due to a reduced use of pesticides and inorganic nutrient application.
111 Many studies have reported that organic farming increases biodiversity in the agricultural
112 landscape, including, for example, carabid beetles (Caprio et al., 2015; Dritschilo & Wanner,
113 1980; Kromp, 1989; Pfiffner & Niggli, 1996;), vascular plants (Hyvönen & Salonen, 2002) and
114 birds (Freemark & Kirk, 2001).
115 Italy houses about 10% of the surface of vineyards in the world (Organisation Internationale
116 de la Vigne et du Vin OIV). The Italian region with largest surface of vineyards is Sicily with
117 over 110'000 ha, followed by Apulia with 96000, Veneto, Tuscany, Emilia Romagna and

118 Piedmont. The percentage of organic vineyards in Italy is about 5.8% (Istat 2010). Several
119 studies have shown that farming systems of vineyards are important factors determining
120 biodiversity of plants and invertebrates (Bruggisser et al., 2010; Caprio et al., 2015; Costello
121 and Daane, 2003; Di Giulio et al., 2001; Thomson and Hoffman, 2007; Trivellone et al.,
122 2012;). For birds, most of the research has addressed the general effect of vineyard
123 agroecosystems on communities (Assandri et al., 2016; Duarte et al., 2014) and populations.
124 The hoopoe (*Upupa epops*), wryneck (*Jynx torquilla*), woodlark (*Lullula arborea*) and
125 common redstart (*Phoenicurus phoenicurus*), for instance, are favoured by patches of bare
126 ground (Arlettaz et al., 2012; Duarte et al., 2014; Schaub et al., 2010; Weisshaupt et al., 2011)
127 within vineyards, indicating that a management that allows a patchy ground vegetation should
128 be beneficial for these species. However, there is paucity of research assessing the effects at
129 finer levels, such as breeding behaviour, habitat selection and movements.

130 The great tit (*Parus major*) is a hole-nesting, insectivorous species whose contribution to pest
131 control in apple orchards has been demonstrated (Mols & Visser, 2002, 2007). At the same
132 time, orchard management may affect its survival and breeding success, reducing food
133 resources and increasing intraspecific competition (Bouvier et al., 2005). In the present study,
134 we examined the effects of vineyard farming systems (i.e. organic vs. conventional) on the
135 feeding ecology of great tits nesting in vineyards of the Langhe and Monferrato wine-producing
136 region, which has been recently marked as an UNESCO World Heritage Site. Here, regional
137 applications of Common Agricultural Policies have promoted the placement of nest-boxes in
138 vineyards to favor hole nesting insectivorous species, which can reduce insect damage and
139 support local biodiversity. We used video-recordings at the nest to assess the number of
140 nestlings fed per visit and their diet, whilst we used radio-telemetry to calculate feeding home
141 range size and habitat selection of male parents.

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2. Material and methods

145 2.1. Study area

146 The study was carried out in the Langa and Basso Monferrato Astigiano (NW Italy), a rural
147 region where vineyards are the dominant cultivation, covering 34% of the territory. Other land
148 uses include oak (*Quercus robur*), chestnut (*Castanea sativa*) and black locust (*Robinia*
149 *pseudoacacia*) woodland (26%), arable land (19%), grassland and pasture (9%) and urban areas
150 (3%). Viticulture in this area is very intensive, and the resulting landscape is dominated by large
151 patches of monoculture, surrounded by forests, crops and grasslands. Vineyards in the study
152 area are kept using the “*Spalliera*” trellising system. It is characterised by low vines (generally
153 < 2 m) supported by wires held between wood or concrete poles. Hedgerows and isolated trees
154 are often severely reduced. Organic vineyards are not abundant in the area and represent 1.86%
155 of total vineyard area (246 ha of organic vineyards over a total cover of 16860 ha of vineyards
156 in the study area). The climate of this region belongs to type Cfa (Temperate, without dry
157 season, hot summer), in terms of Köppen-Geiger’s classification (Peel et al., 2007).

158 We focused on 14 vineyard patches (focal vineyards) in 2011. Vineyard patches were all similar
159 in size, ranging from 7.42 to 9.23 ha (average size: 8.10 ± 0.83 ha). Seven vineyards were
160 certified for organic production, whereby no chemical treatments except sulphur, copper
161 sulphate and pyrethrin sprays were used. The organic vineyard patches were in general adjacent
162 to conventional vineyards and were isolated from other organic vineyards due to the reduced
163 distribution of this kind of management. The other seven vineyards were cultivated with
164 conventional production methods. These involved chemical treatments with pre- and post-
165 emergence herbicides (mostly glufosinate), insecticides (mostly against flavescence dorée),
166 anti-rot compounds, sulphur, copper and zinc sprays, products with esaconazol and copper
167 oxiclорur sulphate against oidium and rots, carbamate pesticides and fungicide, and the use of
168 mineral feeds with average concentration of P, K and N at 6.5 q/ha.

169

170 2.2 Vineyard and surrounding landscape description

171 Focal vineyards were described in terms of habitat composition and management
172 characteristics by means of percentage of grass cover, percentage of soil rubble cover, use of
173 herbicides and/or ploughing (as a presence/absence variable), presence of trees (such as
174 peach, pear and apple) and/or presence of rural building. Habitat differences between the two
175 management systems (i.e. organic versus conventional) were explored using Factor Analysis
176 (FA) (Riitters et al. 1995). We used land cover data digitized from 1:10000 aerial photographs
177 to describe the landscape around the centroid of the focal vineyard patch both at a 500 m and
178 a 1.5 km buffer radius. Seven local landscape variables were measured using a Geographical
179 Information System (ESRI, 2006): the area of forests (FO), grasslands and pastures (PA),
180 shrubs and bushes (BU), vineyards (VI), croplands and orchards (AG), garden patches (OT)
181 and the aggregation index (AI). The AI quantifies the degree of fragmentation of a landscape
182 and is calculated from a patch adjacency matrix, which shows the frequency with which
183 different pairs of patch types appear side-by-side on the map (i.e. the buffer around the focal
184 vineyard patch). Differences in land cover composition within the buffer around the focal
185 vineyards regarding their management system (conventional or organic) were tested using a
186 Kruskal-Wallis test due to non-normal distribution of the data.

187

188 *2.3 Video-recording in nest-boxes*

189 An artificial nest-box was installed as close as possible to the centroid of each vineyard (7
190 organic and 7 conventional). All nest-boxes were successfully occupied and were monitored
191 by means of an infrared CCTV camera (Colour 420 line CCD high resolution camera)
192 connected to a portable digital recorder (JXD990).

193 We recorded nest activity (for a minimum of 1 hour to a maximum of 3 hours per day) every
194 two days during the morning, from egg hatching (day 0) for a total of 8-9 days recorded per
195 nest. All recordings regarded the first clutch. Chicks were ringed and weighed at age 9 days.
196 We recorded each parental visit to the nest-box, registering the sex of the parent and identifying

197 the provisioned prey. Prey was classified as one of the following categories: butterfly's
198 caterpillars (Lepidoptera), Spiders (Araneae) and other preys i.e. items that were brought less
199 frequently, such as snails, or that were not identifiable based on the image analysis (i.e. other
200 adult invertebrates and larvae). From the analysis of the videos, we estimated the time spent by
201 the parents inside and outside the nest (in seconds). The average number of *pulli* fed per visit
202 per nest was tested by means of a Generalized Linear Mixed Model (GLMM), using a Gaussian
203 error distribution, treating nest identity as a random factor.

204 The effect of management system, landscape characteristics (i.e. the area of forests, grasslands
205 and pastures, shrubs and bushes, vineyards, croplands and orchards, and garden patches) in a
206 buffer of 500 m around the nest, the size of the vineyard and the percentage of prey categories
207 identified in each nest was analysed by means of a GLMM with a Gaussian error distribution,
208 treating nest identity as a random factor. Full models were subject to a model reduction
209 procedure whereby non-significant terms were sequentially dropped from a model until only
210 significant terms remained.

211 *2.4 Radiotelemetry*

212 Fourteen birds nesting in nest-boxes (seven in organic and seven in conventional vineyards)
213 were fitted with transmitters. Tags were fitted to males only, to avoid between-sex variation
214 and possible disturbance to incubating females. Individuals were captured using mist nets.

215 One or two 12-m mist nets were placed at some distance from the nest (though along regular
216 flight trajectories) to reduce disturbance.

217 Radio-tags were attached to the base of the central rectrice shafts using cyanoacetate glue and
218 elasticized thread (Kenward, 2001). We used Biotrack PIP31 radio-tags (length 13 mm, width
219 5 mm, height 3 mm) with a weight of 0.35 g. Mean great tit weight was 18.7 g (± 1.7 se, range
220 18.0–20.0 g), hence tags were below the recommended 2% of body weight threshold for tail-

221 mounted tags (Kenward, 2001); mean 1.87% (± 0.06 se, range 1.75–1.94%). Tail-mounted
222 tags were lost during post-breeding moult.

223 Great tit radiotracking started the day after tag attachment and monitoring sessions were
224 distributed equally over the daylight period. We used a Biotrack SIKA radiotracking receiver,
225 with headphones and Yagi antenna. The position of the bird was assessed by triangulation and
226 confirmed visually by two observers separated by 200–250 m from each other and from the
227 nest-box. Observation points were used to allow the best possible view of the home range and
228 to avoid signal loss due to the terrain. The tagged birds were monitored as intensively as
229 possible, collecting the largest number of fixes possible for single individual (Aebischer et al.,
230 1993; Naef-Danzer, 2000). Fixes were recorded every 10 minutes or every two consecutive
231 visits in radiotracking sessions that lasted from 1 to 2.5 hours per day to reduce
232 autocorrelation between fixes.

233 234 *2.4.1 Home-range*

235 Radio-tracking data were used to compute Kernel-based estimators, and we derived 95% and
236 50% Kernel Density Estimator (K95 and K50 respectively) (Gray et al., 2009; Holt et al., 2012)
237 for all fourteen home ranges in ARCGIS 9.2, using Home Range Tool and Hawth's Tools with
238 a kernel smoothing by least squares cross validation. Only fixes of foraging birds were taken
239 into account to describe home ranges. A mean of 77 fixes were obtained for each individual (\pm
240 4 se, range 58–110), which is above the 40 fixes recommended for unbiased estimates of home-
241 range size (Seaman et al., 1999).

242 243 *2.4.2 Compositional analysis*

244 We considered used vs available land cover within the K95 and K50 home-ranges with the
245 relative availability of the land cover around the centroid of the focal vineyards (i.e. a buffer of
246 500 m around each study site).

247 To evaluate hierarchical habitat preferences, we performed a compositional analysis (Aebischer
248 et al., 1993; Holt et al., 2010) using the function “*compana*” in a *dehabitatHS* package in R 3.2.3
249 (R core team 2015).

250 Land cover use values of zero were replaced with a number an order of magnitude smaller
251 than the values for available and used land cover (Aebischer et al. 1993) and 1000 iterations
252 were chosen for data randomization.

253 Habitat types were ranked independently of availability according to the number of positive
254 differences between pairs of habitat types, with paired t-tests used to determine significant
255 differences (Aebischer et al., 1993; Holt et al., 2010). Compositional analysis was performed
256 separately for conventional and organic vineyards to evaluate differences in habitat ranks in
257 the two different managements. Indices of land cover preference were calculated for the K95
258 and K50 of used land cover, by summing log ratios of differences between ranked land covers
259 generated through compositional analysis.

260

261 **3. Results**

262

263 *3.1 Vineyard and Landscape description*

264 The habitat analysis showed that organic differed from conventional vineyards. Factor
265 Analysis identified two axes that represented 87.61 % of the variance, with eigenvalues > 1.
266 The first axis discriminated between conventional (associated with the use of herbicides and
267 the percentage of soil cover) and organic vineyards (associated with the presence of fruit trees
268 and high percentage grass cover values), while the second axis discriminated between sites
269 with or without ploughing between vines (both conventional and organic vineyards could be
270 ploughed) (Fig. 1). The analysis of the surrounding landscape showed that the variables (i.e.
271 area of forests, grasslands and pastures, shrubs and bushes, vineyards, croplands, orchards,
272 garden patches and AI) did not differ significantly between organic and conventional
273 vineyards at the 500 m, nor at the 1.5 km radius scale (results not reported).

274

275 *3.2 Video-recording in nest-boxes*

276 We analyzed 220 hours of recordings from the 14 nests. Females spent more time inside the
277 nest brooding the nestlings than males (GLMM: males -1.159 ± 0.202 , DF 13, t-value: -5.733 ,
278 $P < 0.001$), while males spent on average more time outside the nest looking for food than
279 females (GLMM: males 0.105 ± 0.036 , DF 13, t-value: 2.897 , $P < 0.05$). There was no
280 difference between organic and conventional vineyards regarding the time spent by parents
281 inside or outside the nest-box. The number of nestlings fed per visit by parents was higher in
282 organic than in conventional vineyards (GLMM: conventional vineyards: -0.122 ± 0.041 , DF
283 12, t-value -2.985 , $P < 0.05$) (Fig. 2). When parents fed more than one nestling, they bring
284 small items (i.e. small spiders). The weight of the nestlings at age 9 days (when they were
285 ringed by Enrico Caprio) was significantly higher in organic (average 11.99 ± 0.67 g) than in
286 conventional vineyards (average 10.37 ± 0.63 g) (GLMM: conventional vineyards: $-1.584 \pm$
287 0.360 , DF 116, t-value -4.405 , $P < 0.001$) (Fig. 2). Neither the age of the males nor the clutch
288 size influenced the weight of the nestlings.

289 We monitored 5427 feeding visits to nestlings and successfully identified prey in 55.96% of
290 cases. On average, caterpillars represented 64.01 ± 19.99 %, spiders 6.41 ± 4.71 % and other
291 invertebrates 28.60 ± 16.46 % of items brought by adults. The diet (expressed as percentages
292 of the different items) was unaffected by the management system, but depended on the
293 landscape characteristics around the nest and on the size of the vineyard patch. Caterpillars
294 increased with increasing extent of forests, whereas the other invertebrates increased with the
295 increasing extent of vineyards (table 1). No differences in nestling survival rates between
296 organic and conventional vineyards were detected because all the nestlings successfully
297 fledged and left their nest-boxes.

298 *3.3 Home-range*

299 On average, territory size was between 1 and 2 ha, whereas home range (K95) size varied from
300 5 to 24 ha (table 2). The average home range size of second calendar year great tit males born
301 the year before capture (Euring age code 5) was significantly smaller than that of older
302 individuals (Euring age code 6), independently of the estimator used (K95 or K50) (table 2).
303 The size of home range was independent both of the management system (Kernel 95% $r = -$
304 0.22 , $n = 14$, $P = 0.412$; Kernel 50%: $r = -0.15$, $n = 14$, $P = 0.634$) and of the number of fixes
305 (Kernel 95%: $r = 0.065$, $n = 14$, $P = 0.82$, Kernel 50%: $r = -0.178$, $n = 14$, $P = 0.42$).

306

307 *3.4 Compositional analysis of home-ranges*

308 Compositional analysis of home ranges showed that habitat selection of feeding parents was
309 significantly non-random in relation to habitat availability (Table 3.). Forests were ranked
310 higher than all other habitat types in K95 home ranges, while vineyards were ranked higher in
311 K50 home ranges. There were no differences in the habitat ranking matrices when
312 compositional analysis was performed separately for organic and conventional vineyards.

313

314 **4. Discussion**

315 To our knowledge, this is the first study on the feeding ecology of great tits nesting in vineyards
316 under different management systems. By using video recording and radio-tracking techniques,
317 we assessed the diet and weight of nestlings as well as the provisioning rate, ranging behavior
318 and habitat selection of adults. Landscape variables did not differ significantly between organic
319 and conventional vineyards at the 500 m nor at the 1.5 km radius scale. This suggests that the
320 landscape surrounding conventional and organic vineyards was rather constant and that the
321 selection of nest-boxes within vineyards was not dictated *a priori* by landscape differences.
322 Conventional and organic vineyards differed at the vineyard scale. A high grass cover and the
323 presence of fruit trees characterized organic vineyards, whereas the presence of bare ground
324 and the use of herbicides characterized conventional vineyards.

325 *4.1 Provisioning rate and nestling diet*

326 Despite these differences at the vineyard scale, no differences in provisioning rates were
327 detected, in keeping with previous data suggesting that habitat quality does not necessarily
328 affect feeding rates in great tits (Wilkin et al., 2009). Feeding frequencies are often considered
329 a poor indicator of the amount of food given to nestlings because the size of the prey may vary
330 between feeds (Blondel et al., 1991, Nour et al. 1998). Moreover, higher feeding rates often
331 correlate with smaller prey items, hence resulting in less food being delivered to nestlings
332 (Naef-daenzer, 2000). In our study, more nestlings were fed per visit in organic than in
333 conventional vineyards, and nestlings in organic vineyards were also significantly heavier at
334 the age of nine days. This could indicate that parents were able to find better quality food and
335 a higher abundance of preys and that increasing the number of nestlings fed per visit can be a
336 way to optimize energy spent during feeding activity. During multiple feeding events we were
337 not able to identify the preys, so small items were fed to nestlings. In all the references we have
338 consulted great tits are considered single item feeders and it seems this is the first time this
339 behavior is reported. Although it is possible that suboptimal habitat attracts poorly performing
340 individuals, and that there may be a genetic trait beyond habitat selection and exploration
341 abilities (Dingemanse et al. 2010, Carere et al. 2005) the discrepancies we mentioned above
342 were not mirrored in different nestling survival rates, because, irrespective of the farming
343 system, all the nestlings fledged and left the nest successfully. This confirms that parents are
344 able to adjust their breeding strategies to different habitat conditions (Nour et al., 1998).
345 However, the lower number of nestlings fed per visit and in the lower weight of the nestlings
346 suggest that conventional vineyards offer fewer feeding resources and/or resources of lower
347 quality than organic vineyards, with potential negative effects on survival of juveniles (i.e. post-
348 fledging) (Naef-Danzer, Widmer & Nuber, 2001).

349 The diet of nestlings was unaffected by the management system, but depended on the landscape
350 characteristics in terms of land cover. Caterpillars increased with forest extent whereas other

351 invertebrates increased with vineyard extent, suggesting parents could find the best resources
352 available in each habitat (in keeping with Wilkin et al. 2009). In local vineyards and adjacent
353 forest patches, for instance, ground beetles and spiders are common and usually favoured by
354 organic viticulture (Caprio et al., 2015).

355

356 *4.2 Home ranges*

357 Feeding home range was also independent of the farming system. Home range size ranged from
358 five (for K50) to 10 ha (for K95). Home ranges of great tits breeding in oak-dominated broadleaf
359 forests ranged from 0,33 to 0,42 ha (Naef-Daenzer, 2000), 0,24 to 0,37 ha (Naef-daenzer, 1994),
360 1.18 and 1.34 ha (Krebs 1971). Home range sizes of great tits nesting in vineyards were
361 therefore very large, in keeping with the idea that great tits tend to occupy larger territories in
362 habitats that are suboptimal in terms of resource availability (Krebs, 1971). Also Wilkin et al.
363 (2009) suggested that a possible compensation strategy in response to a shortage of caterpillars
364 may be to enlarge territories, although the responses could vary among individuals (Tremblay
365 et al. 2005, van Overveld & Matthysen, 2010).

366 Compositional analyses of home ranges indicated that habitat selection of feeding parents was
367 non-random in relation to habitat availability and changed according to the distance from the
368 nest-boxes. Parents selected forests when they moved far from the nest and used vineyards
369 when remaining in the surroundings of the nest-box, suggesting that even suboptimal vineyards
370 can be a food source. Great tits in apple orchards have positive effects on pest control (Mols &
371 Visser, 2002, 2007). Our data suggest that this species may also provide a similar ecological
372 function in vineyards. Feeding home ranges depended on the age of males and were larger in
373 adults (Euring age 6), possibly suggesting that more expert males know better the local
374 allocation of feeding resources.

375

376 All in all, despite the relatively small sample size, our results are interesting as they show that
377 the feeding ecology of great tits nesting in vineyards may be affected both by management
378 systems and landscape characteristics. Organic farming systems should therefore take priority
379 in agricultural policies, since they seem to host higher biodiversity (Bengston et al., 2005;
380 Caprio et al., 2015; Hole et al., 2005) and preserve better quality food for great tits and
381 seemingly also for other bird species. Concurrently, conservation of forest lots around the
382 vineyards should be encouraged because they can provide better breeding and feeding
383 opportunities. Heterogeneity of vineyard-dominated ecosystems (which implies the co-
384 occurrence of vineyards and forest patches) may be the pivotal goal, because landscape
385 heterogeneity along with vineyard management may also contribute to supporting a richer bird
386 community (Duarte et al., 2014).

387 **Acknowledgments**

388 We want to thank Monica Chicco, Viola Ferrara and Francesca Morganti for their help during
389 the field work and the owners of the vineyards for their collaboration. We thank Dan
390 Chamberlain for his advice and revision of the English. We are also grateful to two anonymous
391 referees for their constructive comments that improved a previous version of this MS.

392

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638 *Table 1 GLMM of the effect of land cover in a buffer of 500 m around the centroid of the focal*
 639 *vineyard(%) on nestling diet. SD = Standard Deviation, DF = Degrees of freedom. *P < 0.05; **P <*
 640 *0.01; ***P < 0.001; NS Not Significant.*
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		Beta	SD	DF	t-value	P
Percentage of caterpillars						
	Intercept	0.35	0.1	12	5.533	***
	% of forest	0.53	0.1	12	5.03	***
Percentage of spiders						
	Intercept	0.11	0	12	5.31	***
	% of forest	-0.1	0	12	-2.64	*
Percentage of other invertebrates						
	Intercept	0.19	0.1	12	3.59	***
	% of vineyards	0.36	0.2	12	2.41	*

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Table 2 Mean size (ha) of home ranges and territories of great tits according to the age of males.

Estimator	Age		Kruskal-Wallis chi-squared	df	p-value
	6	5			
95% kernel	18.72 ± 8.40	8.46 ± 5.02	4.73	1	0.02
50% kernel	4.23 ± 2.12	1.76 ± 1.42	4.99	1	0.02

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Table 3. Compositional analysis of used vs. available land cover according to different home-range estimators. FO: Forests, VI: Vineyards, GR: Grassland, OA: Other Agriculture, BU: Bushes, OT: Other

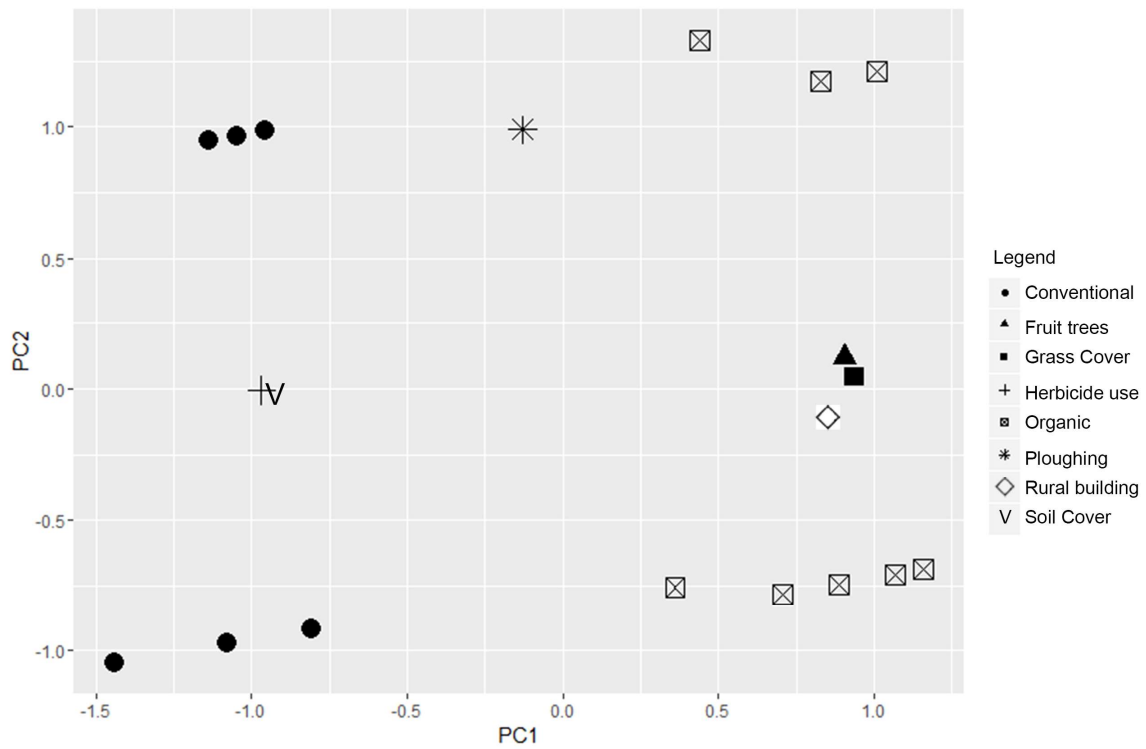
Estimator	Mean ± se	Range	Wilks Lamda	P	Habitat ranking
K95	11.34 ± 2.29	1.35 - 24.89	0.000003	***	FO VI AG BU GR OT
K50	2.64 ± 0.54	0.29 - 5.58	0.000151375	***	VI FO OT AG BU GR

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657 *Fig. 1 Factor analysis of grass cover, soil rubble cover, use of herbicides, ploughing,*
658 *presence of trees (i.e. peach, pear, apple trees) and presence of rural buildings inside the*
659 *vineyards between organic (full circles) and conventional (crossed squares) vineyards*

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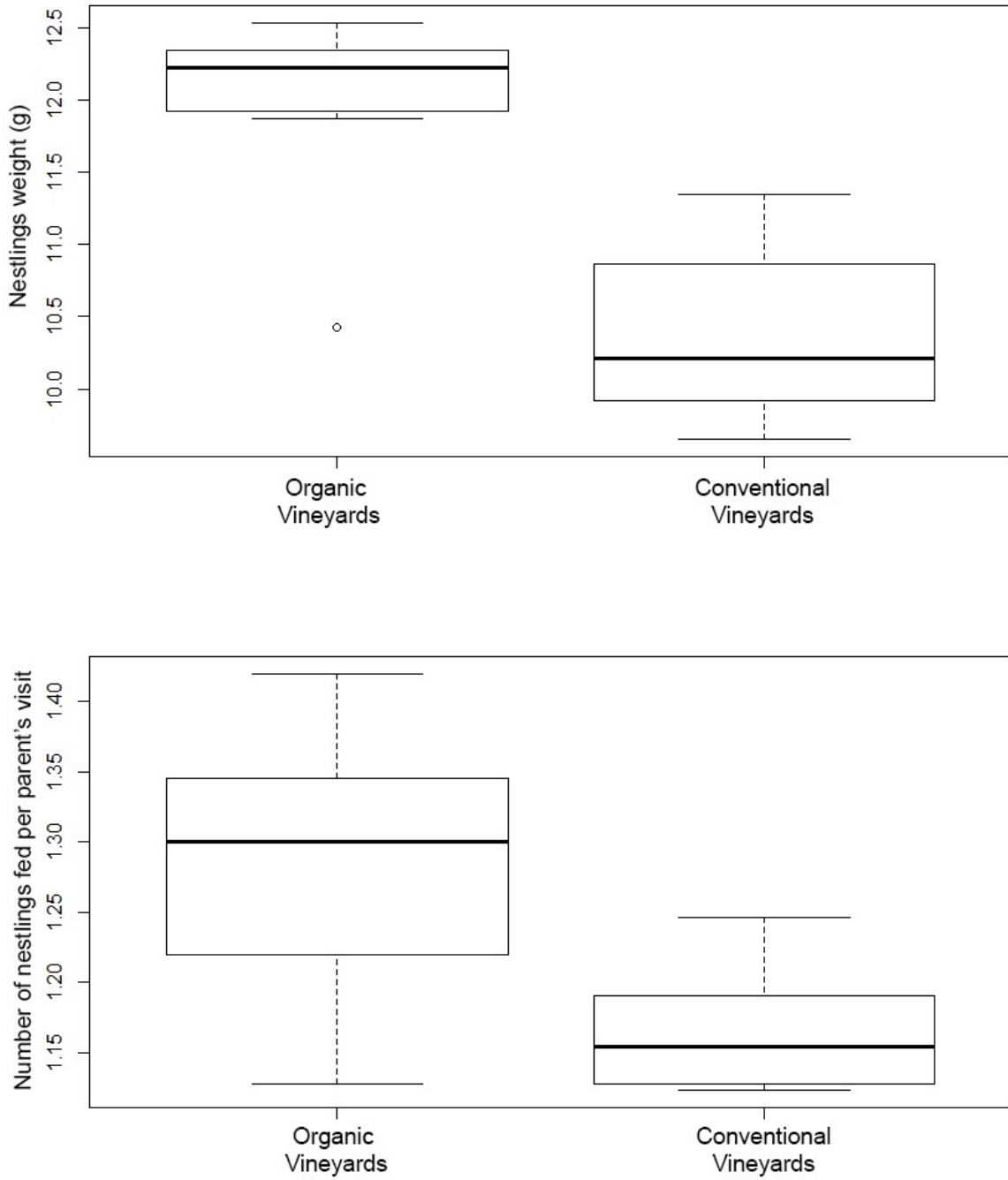
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672 *Fig 2. Boxplot of the average nestling weight (in grams) at age 9 days (top) and the average*
673 *number of nestlings fed per visit by parents (bottom) in conventional and organic vineyards*



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