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## Backyard poultry flocks in France: A diversity of owners and biosecurity practices

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1 **Main title:** Backyard poultry flocks in France: a diversity of owners and biosecurity  
2 practices.

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12 **Abstract (<400) (389 mots)**

13 Over the past few years, the number of backyard poultry flocks has been increasing in France.  
14 A mandatory step to improve backyard poultry management is to assess health risks by  
15 characterizing the flocks and understanding the owners' motivations for keeping poultry and  
16 their husbandry practices. A survey of backyard poultry owners was conducted in France to  
17 gather information about their motivations for owning poultry, flock characteristics, and  
18 breeding and biosecurity practices. The survey was completed by 1,160 owners. The major  
19 motivations for owning poultry flocks were egg consumption (93.3%), recycling (72.4%) and  
20 having pet animals (53.2%). Most owners had already heard about avian influenza (96.7%), but  
21 were less aware about other diseases such as Newcastle Disease (41.6%), salmonellosis  
22 (79.1%), or campylobacteriosis (18.6%). Owners mainly kept only egg-layers (78.4%), and the  
23 median size flock was five egg-layers. Owners gave eggs to their relatives, occasionally or

24 regularly, in 86.6% of the cases. Contacts with other family poultry owners were frequent  
25 (68.9%) and biosecurity practices were poorly implemented: 50% of owners did not wash their  
26 hands systematically after visiting the flock and more than 60% of owners did not wear specific  
27 shoes. Drawing from the survey data, five profiles of family poultry flocks were identified with  
28 multiple correspondence analysis and hierarchical cluster analysis. The profiles, based on flock  
29 characteristics and owners' practices and motivations, illustrate the heterogeneity of the  
30 backyard poultry sector: 1) *urban poultry*, 2) *traditional poultry*, 3) *student poultry*, 4) *pet*  
31 *poultry* and 5) *hobby poultry*. *Urban poultry* consisted of recently constituted (< 2 years old),  
32 small (< 3 birds) flocks of layers, and *traditional poultry* of older, medium-sized flocks  
33 belonging to retired and older people. These two profiles were characterized by limited contacts  
34 (direct or indirect) with other flocks and owners. *Student poultry* consisted of younger owners  
35 (<30 years old) with flocks over 5 years old. *Pet poultry* consist of recently established,  
36 medium-size flocks of layers located in both rural or urban environments. *Hobby poultry*  
37 consisted of dedicated owners who breed and sell poultry and participate in exhibitions and  
38 poultry shows. *Pet* and *hobby poultry* profiles were characterized by greater knowledge of  
39 diseases and biosecurity practices, more bird movements, and reported more frequent clinical  
40 signs. The observation of different profiles can help target veterinary and public health  
41 education messages to prevent disease transmission in backyard poultry flocks in France.

42 **Key words:** backyard flocks, epidemiology, poultry health, biosecurity practices, clustering

43

#### 44 **Introduction**

45 France is known to have a highly diversified poultry production system. As described by the  
46 FAO, 'traditional poultry farming' and 'family poultry' hold a prominent place in the French  
47 poultry production sector (FAO, 2010). Backyard poultry production has indeed maintained  
48 biodiversity, genetic resources, product quality, and local production in France for decades,  
49 leading to an extensive variety of productions and domestic poultry breeds. There are currently

50 320 breeds in the country, of which around 50 are local breeds (FFV, 2020; SCAF, 2020).

51 Over the past few years, the number of backyard poultry flocks has been likely increasing in  
52 France, especially in urban and suburban areas thanks to numerous public initiatives (Dumat et  
53 al., 2018). This increase also has been described in North America. The main reasons identified  
54 behind this phenomenon are a wish to produce healthy and local products, a desire to educate  
55 children to be responsible about the food they eat and a desire to have pet birds (Bailey and  
56 Larson, 2013; Blecha and Leitner, 2014; Mainali and Houston, 2016; Nicholson et al., 2020;  
57 Pires et al., 2019; Pollock et al., 2012; Smith et al., 2012). In France, the vast majority of the  
58 human population now lives in urban areas, and sustainable food projects are developing to  
59 promote the well-being and health of urban dwellers. Over the past 10 years, non-commercial  
60 poultry houses have appeared in private gardens and public spaces, often with the backing of  
61 local authorities, for example to reduce municipal waste (Dumat et al., 2018).

62 While the role of backyard poultry in the dynamics of Highly Pathogenic Avian Influenza  
63 (HPAI) is likely limited in most cases (Souvestre et al., 2019), two outbreaks of HPAI subtype  
64 H5N8 were detected in November 2020 in poultry pet shops in two separate regions of France  
65 (Corsica (2B) and the Yvelines (78)) (MAA, 2020a, 2020b). Both shops shared the same bird  
66 supplier (Amat et al., 2020). This suggests that under certain circumstances, backyard poultry  
67 could play a role in the spread of avian influenza viruses (Fiebig et al., 2009; Van Steenwinkel  
68 et al., 2011). Moreover, many backyard poultry owners lack experience and knowledge about  
69 poultry health and breeding practices, which may pose an additional risk with regard to other  
70 zoonotic diseases, such as salmonellosis and campylobacteriosis (Anderson et al., 2012, 2016;  
71 Behravesh et al., 2014).

72 Understanding the characteristics, movement networks and disease management practices of  
73 backyard flocks is essential to identify potential disease transmission pathways and develop  
74 education programs adapted to different target populations. A survey of backyard poultry

75 owners was carried out in France to gather information about flock characteristics (e.g., flock  
76 size, species, location), management and biosecurity practices (e.g., bird movements, flock  
77 health), and owner characteristics (including their motivation to own poultry). Cluster analysis  
78 was used to identify different profiles and highlight the diversity of backyard poultry flocks.  
79 This study is a first step towards achieving a better understanding of the backyard flock  
80 population in France.

## 81 **Material and methods**

### 82 *Study design*

83 A cross-sectional study was conducted in France among backyard poultry owners. To be  
84 eligible to participate in the survey, respondents had to be at least 16 years old, live in mainland  
85 France and Corsica, and keep between 1 and 250 chickens (*Gallus gallus*) at the time of the  
86 survey. Respondents were recruited by means of an online survey that was conducted across  
87 France from June 2018 to September 2020.

88

### 89 *Recruitment of participants*

90 The on-line survey was advertised through different means: (1) posts on social networks  
91 through Facebook® backyard poultry groups and dedicated poultry websites, (2) e-mails sent  
92 to all French veterinary students (Toulouse, Lyon, Paris and Nantes National Veterinary  
93 Schools) asking them to participate in the survey themselves and to advertise it in turn, and (3)  
94 flyers, posters and printed questionnaires provided to pet and animal food shops, veterinary  
95 practices and poultry exhibitions in a 10-kilometers radius from the city center of Toulouse  
96 (Haute Garonne, France), in order to ensure to have enough recruitments from urban and  
97 suburban areas.

### 98 *Questionnaire development*

99 The questionnaire was designed to obtain information about backyard poultry flocks. It  
100 comprised 30 questions divided into five sections: 1) owners' characteristics, demographics,  
101 socio-professional category and knowledge about diseases (n=6), 2) flock characteristics (n=4),  
102 3) poultry husbandry and bird movements (n=9), 4) biosecurity practices (n=7) and 5) flock  
103 health (n=4). Open (n=3) and closed (n=27) questions were used. For some closed questions,  
104 respondents could select several answers. When precision was needed, questions incorporated  
105 an 'other' option that offered the respondent an opportunity to write an answer. The  
106 questionnaire was experienced by six owners who were not included in the analysis, and the  
107 time to complete the questionnaire did not exceed ten minutes. The online questionnaire was  
108 created using Sphinx iQ 2 © software and is available at the link <http://bit.ly/poulepec>. The  
109 questionnaire is available in English upon request to the corresponding author.

#### 110 *Data analysis*

111 The questionnaire items were coded into 62 variables that were then used to perform the  
112 statistical analyses. Most of the questions were binary (yes/no) or multiple choice. Some  
113 variables (e.g., *self-estimated knowledge* about *Campylobacter* and *Newcastle* disease) were  
114 considered as a proxy to estimate the technical or public health knowledge of owners. The  
115 variable *urban* was created based on the mean population density of every respondent's  
116 commune (the information was obtained by registering the official geographical code for each  
117 flock (INSEE, 2021)). As the variables did not follow a normal distribution, associations  
118 between categorical variables were determined using a non-parametric Fisher test. After  
119 combining distinct variables into new ones and removing some variables due to an absence of  
120 variability between respondents and/or lack of relevance, 49 variables were introduced in the  
121 multiple correspondence analysis (MCA). The profiles of backyard poultry owners were  
122 computed using the MCA followed by a hierarchical cluster analysis (HCA) (Costard S., 2009;  
123 Delpont et al., 2018; Martínez-García et al., 2015). The MCA method allows the number of

124 variables to be reduced by creating synthetic variables (also known as dimensions or factors)  
125 which maximise the dataset variance in a lower dimensional Euclidian space. The synthetic  
126 variables are then used in the HCA. For the MCA, out of 49 variables, 34 variables were  
127 considered to be active variables and 14 were considered as supplementary, such as *clinical*  
128 *signs* and *treatments*, and were used to help interpret the data. The HCA was performed based  
129 on the minimum number of factors from the MCA accounting for 50% of the data variance.  
130 The HCA used Ward's method and was consolidated with the K-means method.

131 The over-representation of variable outcomes in each profile generated by the HCA was  
132 assessed with a hypergeometrical test (Husson et al., 2017). P-values indicate the strength of  
133 the category related to the profile's population: \* when the p-value is < 0.05, \*\* when the p-  
134 value is < 0.01, \*\*\* when the p-value is < 0.001 (Table 2.1 to 2.5). All statistical analyses were  
135 computed on R 4.0.2 and RStudio software Version 1.3.1093 (R Core Team, 2020; RStudio  
136 Team, 2020). The MCA and the HCA analyses and graphical outputs were computed with  
137 "FactoMineR" (Lê et al., 2008).

## 138 **Results**

### 139 *Descriptive analysis*

#### 140 *Flocks and owners' characteristics*

141 A total of 1,258 backyard poultry owners returned the survey (37 completed paper  
142 questionnaires, 23 paper questionnaires were retrieved from veterinarians and 1,198 completed  
143 online questionnaires). Only fully completed questionnaires were kept for analysis (n=1,160).  
144 Respondents were located in 95 French departments, covering the entire territory of France  
145 (Figure 1). Southwest France was the most represented with 18.6% (n = 216/1160) of  
146 participants in the department of Haute-Garonne. Flocks were equally distributed between rural

147 (n = 402/1160, 34.7 %), urban (n = 406/1160, 35.0%) and suburban areas (n = 352/1160, 30.3%)  
148 (Table 1.1).

149 The median number of birds per flock was 5 [Q1 = 3, Q3 = 9.5] (Table 1.2). Flock size was  
150 higher in rural compared to urban areas (p-value<0.001) (Figure 2.A). A majority of flocks held  
151 only chickens (n = 909/1160, 78.4 %) (Figure 2.B). Owners reported having their flocks for  
152 less than five years in a majority of cases (n = 635/1160, 62.9%) and younger flocks (<2 years  
153 old) were more present in urban compared to rural areas (p-value<0.001). The most highly  
154 represented owners were between 30 and 49 years old (n = 564/1160, 48.6%) and were senior  
155 managers from public or private institutions and employees (respectively n = 336/1160, 29.0%  
156 and n = 281/1160, 24.2 %) (Table 1.1). The two main motivations for owning poultry birds  
157 were local egg consumption and recycling kitchen leftovers; only 6.3% of owners claimed to  
158 have other motivations for owning poultry (Figure 3.A).

#### 159 *Flock husbandry and moving birds*

160 A majority of owners claimed to visit their flock twice a day or more (n = 928/1160, 80.0%)  
161 and to clean the coop weekly or monthly (n = 882/1160, 76.0%). The most frequently used feed  
162 were kitchen leftovers (n = 880/1160, 75.9%) and a complete cereal mix bought from pet shops  
163 (n = 547/1160, 47.2%) (Table Appendix 1.1). In rural areas, owners were more likely to feed  
164 their poultry with a homemade mix (p-value<0.001).

165 Over half of the flocks had introduced birds in the last year (n = 729/1160, 62.8%). The  
166 frequency of bird introductions was more important in rural areas (p-value<0.001) and in bigger  
167 flocks (p-value<0.01). Rural owners were more in contact with other owners (p-value<0.001).  
168 The main source of introduction were ready-to-lay hens (n = 744/1160, 64.1%) and came  
169 directly from professionals or private breeders. The origin of introduced birds varied depending  
170 on the age of the owner. Younger owners (< 30 years old) were more likely to buy birds directly



171 from professionals or private owners, whereas older people bought their birds from live-bird  
172 markets or pet shops (p-value<0.01). The age of birds at introduction differed between owners.  
173 Introducing chicks and fertile eggs was more frequent in rural areas for hobby breeders, while  
174 ready-to-lay hens were mainly introduced in urban areas for food waste recycling (p-  
175 value<0.05). With regard to mortality management, dead birds were either buried in the garden  
176 (n = 552/1160, 47.6%), disposed in the municipal waste (n = 239/1160, 20.6%), burned  
177 (n=79/1160, 6.8%), given to wild animals (n=76/1160, 6.6%) or brought to the veterinarian  
178 (n=67/1160, 5.8%). Some owners had not yet dealt with the death of a bird (n=70/1160, 6.0%),  
179 and a minority declared that they had slaughtered bird(s) to eat (n=14/1160, 1.2%) (Table  
180 Appendix 1.1).

### 181 *Public and poultry health*

182 Figure 3.B shows the proportion of flocks featuring risky biosecurity practices and behaviour  
183 associated with the transmission of pathogens. The most common identified practices were to  
184 distribute eggs (from time to time or regularly) outside the family unit (n = 1005/1160, 86.7%)  
185 and to have regular contacts with other owners (799/1160, 68.9%). A majority of owners (n =  
186 641/1160, 55.3%) appeared unaware of the risk represented by wild avifauna (they had wild  
187 bird feeders in the garden) (Table Appendix 1.2). Compliance with biosecurity measures such  
188 as washing hands and wearing specific shoes was irregular. The study showed that 13.5% of  
189 owners (n = 157/1160) washed their eggs after collection or before consumption, with these  
190 owners more represented in urban areas (p-value<0.05).

191 In the year prior to the survey, 37.5% (n = 435/1160) of flocks showed clinical signs of disease  
192 and more than half of their owners had consulted a veterinarian (Table Appendix 1.3). The  
193 frequency of vet consultations increased significantly with flock size. Concerning therapeutics,  
194 48% of owners declared that they had given a 'treatment', most of these being pest control,

195 alternative solutions (phytotherapy and homeopathy), deworming, and vitamins (Table  
196 Appendix 1.3).

### 197 ***Backyard poultry flock profiles***

198 The first two dimensions of the MCA accounted respectively for 8.39 and 5.18% of the total  
199 variance, and the first 16 dimensions accounted for 53.48% of the cumulative variance of the  
200 dataset. The HCA revealed five poultry owner profiles: *urban poultry*, *traditional poultry*,  
201 *student poultry*, *pet poultry* and *hobby poultry*. Data obtained by MCA are graphically  
202 represented as a cloud of dots in a high dimensional Euclidian space summed up in a lower  
203 dimensional approximation given by synthetic axes (or dimensions). Groups of points are  
204 identified by HCA in the MCA. Figures 4A and 4B summarize the information obtained by  
205 MCA and HCA considering the three first dimensions.. The first dimension (Dim 1) was best  
206 described by the following variables: size of the flock, mixed species, bird-selling activity,  
207 clinical signs of disease and treatment use. The second dimension (Dim 2) was best described  
208 by the owners' socio-economic category, the age of the flock, the cleaning frequency and the  
209 food origin. Details of variable distributions within each profile and whether their outcomes  
210 were over-represented are presented in supplementary materials (Tables Appendix 2.1 to 2.5).

211 *Urban poultry*: This profile mostly comprises recent flocks (< 2 years old) with three or less  
212 birds and no mixed species or exotic birds (98.7%,  $p < 0.001$ ). Owners were mainly medium-age  
213 senior managers. Flocks were located in higher proportions in urban and suburban areas  
214 compared to other clusters (respectively 46.4%  $p < 0.001$ , 36.7%  $p < 0.05$ ) (Tables Appendix 2.1  
215 and 2.2). The bird introduction rate was low and consisted mainly in the introduction of ready-  
216 to-lay hens (Table Appendix 2.3). A washing eggs practice was observed (21.3%  $p < 0.001$ ), but  
217 no specific knowledge about poultry diseases was reported (Table Appendix 2.1). Observed  
218 clinical signs, vet consultations and the use of treatments were underrepresented (Table  
219 Appendix 2.5). However, owners who gave treatments to their birds claimed to buy these in pet

220 shops essentially (61.1%  $p < 0.001$ ). Owners putting dead birds into municipal waste were  
221 overrepresented (25.4%  $p < 0.01$ ) compared to other profiles (Table Appendix 2.4).

222 *Traditional poultry:* This profile comprises medium-sized (3-10 birds) flocks that were over 5  
223 years old (73.9%  $p < 0.001$ ) and were mainly in rural areas (45.0%  $p < 0.001$ ). Owners over 50  
224 years old were overrepresented, they preferentially gave food leftovers and homemade feed  
225 mixes and they did not have specific knowledge about poultry diseases (Table Appendix 2.1).  
226 Bird introduction was rare and birds came from pet shops or live-bird markets (Table Appendix  
227 2.3). Observed clinical signs, vet consultations and the use of treatments were underrepresented.  
228 Owners mainly bought their treatments from pharmacies or over the internet, or used natural  
229 homemade products (54.5%  $p < 0.001$ ) (Table 2.5).

230 *Student poultry:* Flocks over 5 years old and presenting spent-laying hens were more  
231 represented in this profile. Owners were students under 30 years old and fed their birds food  
232 leftovers and homemade feed mixes. They usually had technical and disease knowledge despite  
233 poor biosecurity practices (Tables Appendix 2.1 and 2.4). Observed clinical signs, vet  
234 consultations and the use of treatments were underrepresented (Table Appendix 2.5).

235 *Pet poultry:* Flocks were of medium size, recent ( $< 2$  years old) and consisted of chickens only.  
236 Medium-age and intermediate profession owners were well represented in this profile. The  
237 main motivation for owning poultry was having pets. Owners had technical and disease  
238 knowledge (Tables Appendix 2.1 and 2.2). Concerning biosecurity practices, this profile  
239 showed a higher implementation of washing hands and wearing specific shoes. It also presented  
240 a higher introduction rate and closer contacts with other flocks and owners (Table Appendix  
241 2.4). Most of the flocks showed clinical signs over the past year (58.1%  $p < 0.001$ ). Owners used  
242 a variety of treatments such as antimicrobials, deworming and pest-control treatments, vitamins  
243 and alternative treatments coming from veterinarian clinics (Table Appendix 2.5). Owners of  
244 this profile principally buried carcasses in their garden (54.3%  $p < 0.01$ ) (Table Appendix 2.4).

245 *Hobby poultry*: These flocks had the highest number of birds (> 10 birds in 85.3% of cases,  
246  $p < 0.001$ ). Flocks were over 5 years old (51.5%  $p < 0.001$ ), showed mixed species (49.0%  
247  $p < 0.001$ ) and were located in rural areas (47.5%  $p < 0.001$ ) (Table 2.2). Keeping poultry as a  
248 hobby was the main motivation in this profile (54.9%  $p < 0.001$ ). Many introductions were  
249 observed and introducing chicks or fertile eggs bought from private breeders or owners were  
250 over-represented (Table Appendix 2.3). Bird selling and movements also were an important  
251 feature. Homemade feed mixes were preferentially given to flocks (like in the *traditional* and  
252 *student* poultry profiles). As in *pet* poultry, owners showed a higher implementation of  
253 biosecurity practices and higher poultry owner contacts. For carcasses, owners used different  
254 ways of elimination such as burning, leaving carcasses with the vet or other methods. The main  
255 'other method' described was leaving carcasses in a wild environment for necrophage  
256 consumption (Table Appendix 2.4). Clinical signs were overrepresented in this profile,  
257 especially respiratory signs, digestive signs and to a lesser extent locomotor signs (respectively  
258 44.1% ( $p < 0.001$ ), 16.2% ( $p < 0.01$ ), 8.3% ( $p < 0.05$ )). As in *pet* poultry, all kinds of treatments  
259 were used and mainly bought from veterinarian clinics (Table Appendix 2.5).

## 260 **Discussion**

261 This study characterized the backyard poultry compartment in rural, suburban and urban areas  
262 across France using data collected during a two-year period (2018-2020). Until now, little  
263 information was available in France on this compartment and none of the existing data aimed  
264 to characterize practices, flocks and owners.

265 Our study showed that a vast majority of flocks had existed for less than five years within  
266 households, and that one third were located in urban or suburban areas. Flocks from urban areas  
267 were smaller compared to rural areas. This could be explained by the limited space in high-  
268 density populated areas (Elkhoraihi et al., 2014). The urbanization of family poultry observed  
269 in France has been described in other countries of Europe as well as in the USA throughout the

270 past decade (Elkhoraibi et al., 2014; Garber et al., 2007; Karabozhilova et al., 2012; Madsen et  
271 al., 2013). The main motivations for having birds seems to have changed in correspondence  
272 with this demographic change. In addition to egg consumption, recycling food leftovers, hobby  
273 activity and considering birds as pets, other motivations were found, in line with existing studies  
274 (Elkhoraibi et al., 2014; Garber et al., 2007; Pollock et al., 2012). Moreover, nearly a quarter of  
275 participants identified hobby poultry as the main motivation for keeping birds, which included  
276 breeding ornamental birds, preserving genetic diversity - pedigree fowl and poultry, poultry  
277 shows and exhibitions activities. This motivation also has been described in other countries  
278 such as the USA (Burns et al., 2013; Elkhoraibi et al., 2014; Garber et al., 2007).

279 The present study showed a wide heterogeneity of practices and identified five different  
280 profiles: *urban*, *student*, *traditional*, *pet* and *hobby poultry*. *Hobby* and *traditional backyard*  
281 *poultry* seem to correspond to the two categories of family production defined by the FAO and  
282 were mainly represented in rural areas (FAO, 2010). The three other profiles (*urban*, *student*  
283 and *pet poultry*) included mainly recent flocks and reflected the growing interest for keeping  
284 poultry, especially in urban areas, that has been documented worldwide (Blecha and Leitner,  
285 2014; Elkhoraibi et al., 2014; Karabozhilova et al., 2012; Nicholson et al., 2020).

286 *Traditional* and *pet poultry* flocks were larger than their *urban* counterparts but remained  
287 smaller than *hobby* flocks. Elkhoraibi et al. showed that chick production was more frequent in  
288 large flocks and this could be the case for the *hobby poultry* profile described in our study  
289 (Elkhoraibi et al., 2014). The key characteristics of the *hobby* profile are more frequent bird  
290 selling, better technical/disease knowledge, and a higher rate of introduction of chicks and eggs  
291 within the flock.

292 *Student* and *traditional poultry* could not be differentiated by their management practices; they  
293 mainly differed according to the age and type of owner (student vs retired). Introduced birds  
294 from *traditional* and *students'* flocks were mainly spent laying hens. The localization of

295 traditional flocks in rural areas close to commercial poultry farms could facilitate the  
296 introduction of spent laying hens due to close human links (Van Steenwinkel et al., 2011).

297 *Pet poultry* was a recent profile, located in all types of living environments and more likely to  
298 have access to veterinary services. These results showed that *pet poultry* owners acquired  
299 significant knowledge of husbandry and diseases, potentially related to the observations of  
300 clinical signs in their flocks, leading to personal research and specific advice from their  
301 veterinarian. In contrast, *urban* owners had less technical and disease knowledge compared to  
302 *pet* and *hobby* breeders, probably due to the small flock sizes and the absence of clinical signs.  
303 However, risky practices were identified in *urban* flocks: disposing dead birds in municipal  
304 waste and washing eggs before consumption. Disposing dead animals in household waste is  
305 forbidden in France (*Loi n° 96-1139 du 26 décembre 1996 relative à la collecte et à*  
306 *l'élimination des cadavres d'animaux et des déchets d'abattoirs et modifiant le code rural,*  
307 1996) and can lead to epidemic outbreaks and/or human exposure to antimicrobial resistance  
308 (Alam et al., 2019; Pollock et al., 2012; Walz et al., 2018). Washing eggs after collection  
309 increases the risk of foodborne outbreaks, especially *Salmonella* infections (Hutchison et al.,  
310 2003). While prevalence levels of *Salmonella* sp. are not known in French backyard poultry  
311 flocks, bacteria were isolated in respectively 10 and 12% of backyard flocks in South Australia  
312 and Ontario (Brochu et al., 2019; Ferreira et al., 2020; Manning et al., 2015; Zhao et al., 2016).  
313 These observations highlight the importance of educating poultry owners about health  
314 regulations, zoonotic diseases and preventive measures, especially in urban areas (Pollock et  
315 al., 2012; Tobin et al., 2015).

316 With regard to biosecurity practices, their higher implementation in *pet* and *hobby poultry* could  
317 be explained by the higher prevalence of observed clinical signs compared to *urban, traditional,*  
318 and *student poultry*. It is possible that owners whose flocks had no clinical signs did not have  
319 any incentive to implement biosecurity practices or gain knowledge about poultry health. On

320 the other hand, apparent clinical signs in *pet* and *hobby poultry* showed that the biosecurity  
321 practices observed were insufficient and could be improved, especially by implementing  
322 preventive measures surrounding bird movements, such as quarantine or rest days in live bird  
323 markets (Burns et al., 2011; Fournié et al., 2011).

324 The 1999-2000 H7N1 AIV outbreak in Italy (Capua et al., 2003; Terregino et al., 2007), the  
325 2003 H7N7 epidemic in the Netherlands (Bataille et al., 2011) and the 2017 outbreak of HPAI  
326 H5N8 (Guinat et al., 2020) in France identified human movement with infected birds as major  
327 risk factors in the spread of HPAI. In addition, Burns has emphasized the importance of indirect  
328 contacts between backyard-flock owners within the backyard poultry sector, especially for  
329 *hobby poultry* (Burns et al., 2011). Another important aspect to consider is the connectedness  
330 of backyard flocks with commercial poultry flocks, thus highlighting the specific need to  
331 improve poultry health in both the backyard and commercial poultry sectors to prevent diseases  
332 from circulating between the two (Fiebig et al., 2009; Souvestre et al., 2019).

333 As family poultry flock demographics have been poorly described in France, it is difficult to  
334 estimate the representativeness of our sample. With the increase of chicken coops in urban and  
335 suburban areas over the past decade, the FAO estimation of flock sizes could be consequently  
336 increased (Dumat et al., 2018; FAO, 2010). The study covered the entire country, suggesting  
337 that the diversity of backyard flocks was taken into account. However, the department of Haute-  
338 Garonne (31) was the most represented in the survey due to more extensive advertising there.  
339 As the Haute-Garonne comprises the urban and suburban area of Toulouse, this may have  
340 artifactually increased the *urban poultry* profile. Furthermore, it is likely that this study  
341 underrepresents the prevalence of rural flocks which could be owned by retired owners with  
342 limited internet access. Similarly, student owners were overrepresented due to the diffusion of  
343 the questionnaire in French veterinary schools.

344 This cross-sectional survey was diffused for a quite long period of time (two years and two  
345 months) in order to give time the owners to respond and to ensure to have a large enough  
346 sample. Despite this long period, we didn't expect any significant evolution in the target  
347 population. Indeed, even if turnover may be important in backyard poultry, a majority of flocks  
348 are owned for more than two years in our study (71.4%), and one study shown that, in the mean,  
349 no more that 50% of owners acquire news birds in the 12 months preceding the survey (Beam  
350 et al., 2013).

351 Self-estimated questions could introduce a bias between obtained data and reality (Nespeca et  
352 al., 1997). Indeed, it could lead to underreported clinical signs in birds in *urban poultry* due to  
353 the owners' lack of disease knowledge, or, to the contrary, along with *pet poultry*, closer  
354 attention to clinical signs could be due to considering birds as pets in comparison to *traditional*  
355 *poultry*. In addition, biosecurity practices could be overreported in *hobby poultry* and could be  
356 explained by the fact that the owners know the right attitude to adopt regarding their flock  
357 without actually implementing the necessary measures.

358 This study provides for the first time a description of backyard flocks in France and shows  
359 heterogeneity in their profiles, in particular with regard to flock characteristics, and owners'  
360 motivations to own poultry, knowledge and observation of clinical signs. Results can be used  
361 to develop targeted strategies to prevent disease transmission in the non-commercial poultry  
362 sector. Collaboration between veterinary authorities and chickens, feed and equipment retailers  
363 should be established in order to deliver good quality and standardized information to poultry  
364 owners, for example in the form of illustrated information booklets or videos regarding  
365 regulations, diseases and welfare. As internet is often used by owners as the main source of  
366 information, the creation of websites dedicated to backyard poultry would be a pertinent  
367 interface for private owners as well as poultry professionals of this sector, in order to fill the



368 “communication gap” as previously mentioned (Karabozhilova et al., 2012). Also, according  
369 to our results, it will allow to adapt message to the owner profiles and argue for flock registering.  
370 Our study showed veterinary solicitations were limited even in case of clinical signs of diseases  
371 and confirm what was already shown (Karabozhilova et al., 2012). In order, to facilitate contact  
372 between owners and veterinarians, the latter should be informed and trained to manage this new  
373 emerging field of pet-poultry, and more identified as competent professional to provide advice  
374 on flock management, zoonotic prevention and poultry welfare to be able to meet owners’  
375 expectations (e.g., wanting ‘Happy, healthy chickens’) (Crespo et al., 2010). The presence of  
376 chemical residues in eggs after treatments also is an important issue for public health. Indeed,  
377 veterinarians have a limited choice of approved and adapted (e.g., small quantities) treatments,  
378 and may use drugs that could generate residues in eggs. (Marmulak et al., 2015; Whitehead M.  
379 L. and Roberts V., 2014). The development of specific products and vaccines for backyard  
380 poultry (i.e. for small flocks) would be of great interest.

381 Social network analysis between the five profiles identified could provide additional data  
382 regarding bird movements, their health status and owners’ sources for seeking information, and  
383 thus enable targeted recommendations to “key” actors.

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390 l’Alimentation, Ministère de l’Agriculture et de l’Alimentation, France.

#### 391 **Conflicts of interest**

392 The authors have no conflicts of interest involving the findings of this study to declare.

### 393 **Data Availability Statement**

394 The data that support the findings of this study are available from the corresponding author  
395 upon reasonable request.

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558 **Figure captions**

559 **Figure 1:** Backyard flock repartition of the 1,160 participants in the survey used for analysis  
560 per French INSEE code area. Number of backyard poultry flocks participating in each  
561 department are shown using a different colour code.

562 **Figure 2:** Flock characteristics: A) Size of the flocks depending on the living-environment of  
563 the owner and B) Proportion of species other than chickens and/or layers.

564 **Figure 3:** Owners' motivation (A) and biosecurity practices (B).

565 **Figure 4:** Projection of the 1,160 Backyard Poultry Flocks (BPF) on the three first dimensions  
566 by the HCA. A) Profiles are represented on axes of dimension 1 and 2. B) Profiles are  
567 represented on axes of dimension 1 and 3.

569 **Table 1.1:** Cross-sectional study of 1,160 French backyard poultry owners. Frequency of categories related to owners' characteristics,  
 570 demographics, socio-economic category and knowledge about diseases.

<b>Variable and definition</b>	<b>Categories</b>	<b>%</b>
Age of owner at the time of the survey	[16-29] years old	18.6
	[30-49] years old	48.6
	[50-64] years old	26.9
	≥ 65 years old	5.9
Socio-economic category of the owner	Farmers	3.7
	Artisans. Merchants. Entrepreneurs	7.8
	Senior manager in private or public service. Intellectuals and artists	29
	Intermediate professions (technicians, associate professionals)	5.9
	Employees	24.2
	Workers	3.7
	Old-age pensioners	10.3
	Inactive people	5
	Students	10.3
Owners' motivation for having poultry	Pet animal	53.2
	Hobby and local breeds	22.1
	For egg quality	93.3
	For recycling food waste	72.4
	Other motivation	6.89
Owner aware of the existence of Salmonella spp. as a pathogen	No	20.9
	Yes	79.1
Owner aware of the existence of AIV as a pathogen	No	3.3
	Yes	96.7
Owner aware of the existence of Campylobacter spp. as a pathogen	No	81.4
	Yes	18.6
Owner aware of the existence of NDV as a pathogen	No	58.4
	Yes	41.6
Density population according to the BPF localization	Rural	34.7
	Sub-urban	30.3
	Urban	16.7



	Ultra-urban	18.3
Owners giving or selling eggs produced from their flocks	Never	13.4
	Sometimes	54.3
	Regularly	24.4
	Always	7.9
Owner volunteering for further participation to the study	No	43.4
	Yes	56.6

571

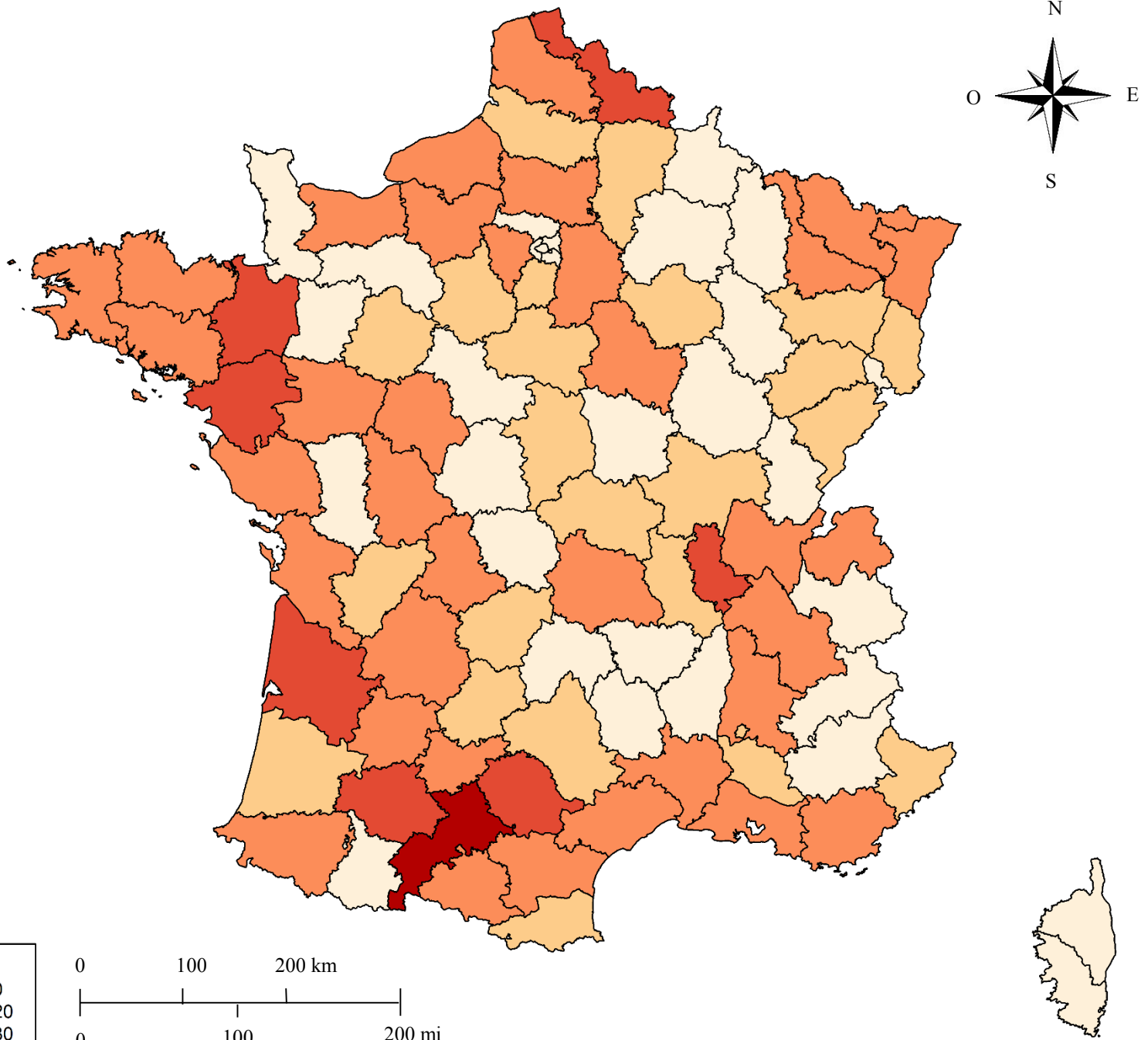
572 **Table 1.2:** Cross-sectional study of 1,160 French backyard owners. Frequency of categories related to flock characteristics: size, species and age.

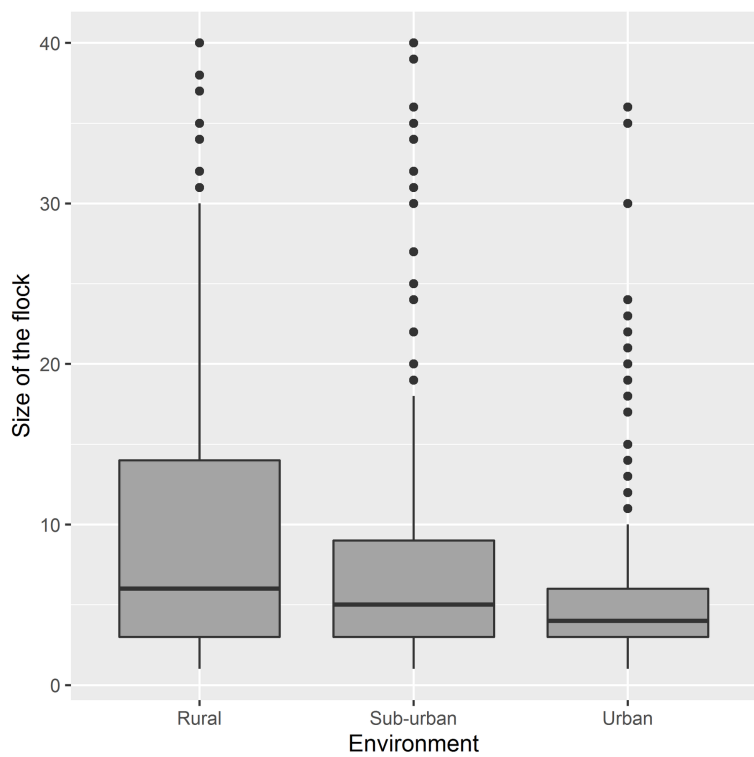
573

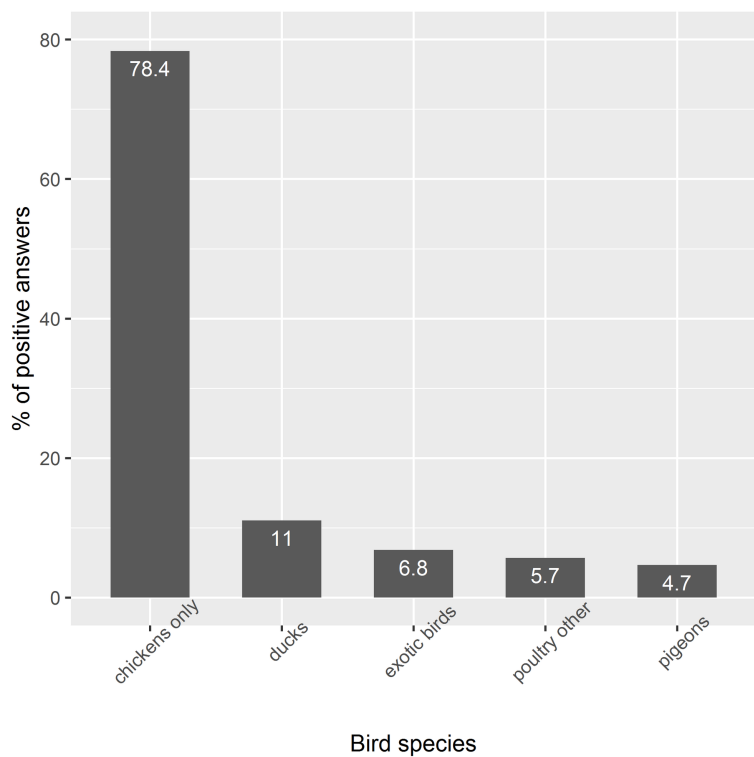
Variable and definition	Categories	%
Number of layers or chickens in the BPF	Q1 = 3    Median = 5	Q2=9.5
	≤3	33.7
	>3 and ≤ 10	42.3
	>10	24.0
Age of the coop and first associated poultry (years old)	< 2	28.6
	[2-5]	34.2
	[5-10]	20.5
	[10-30]	11.6
	≥ 30	5
Other bird species	No	78.4
	Yes	21.6
Presence of ducks or geese	No	89
	Yes	11
Presence of other poultry species (turkeys, guinea fowl, quail)	No	94.3
	Yes	5.7
Presence of pigeons	No	95.3
	Yes	4.7
Presence of exotic birds	No	93.2
	Yes	6.8

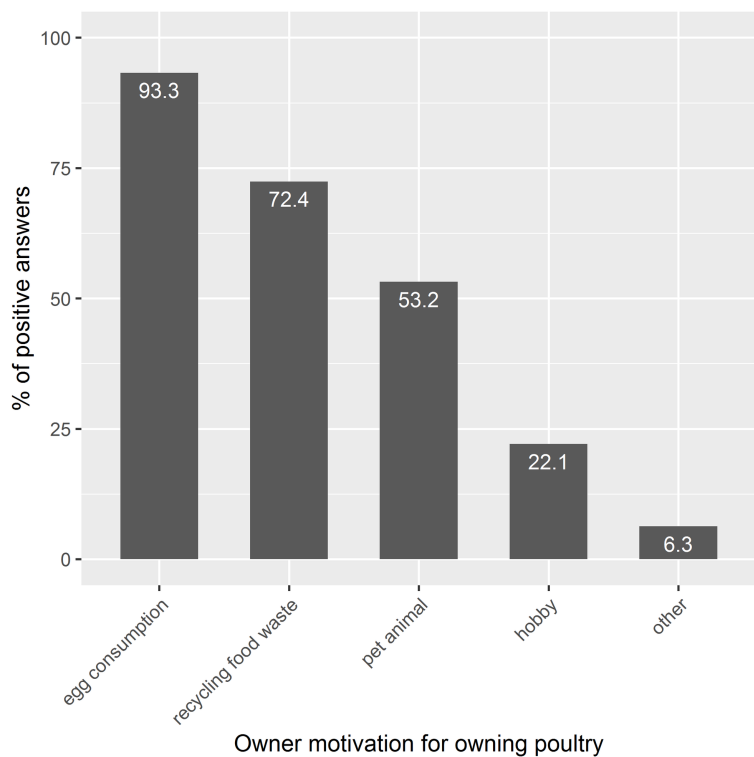
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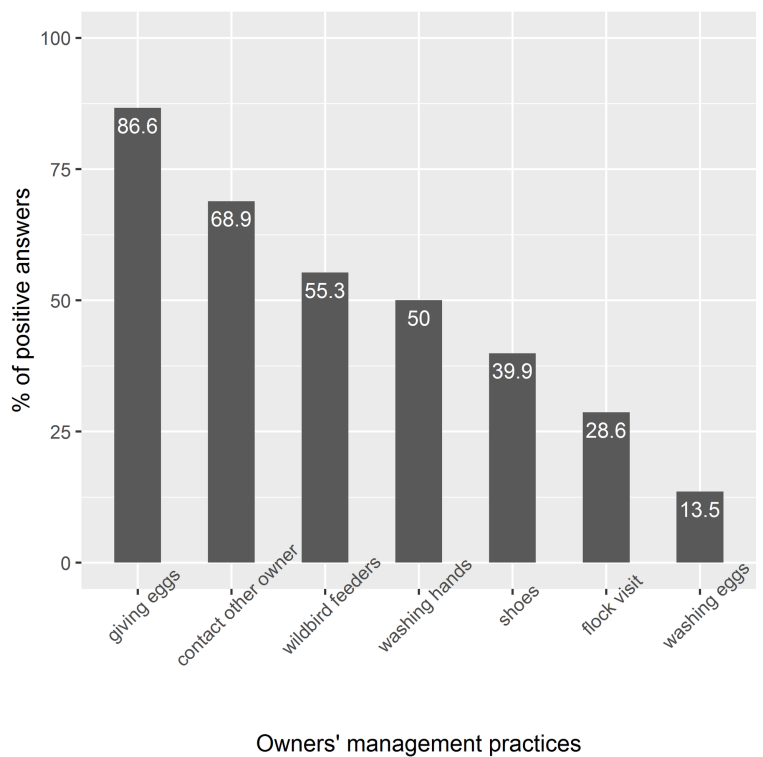
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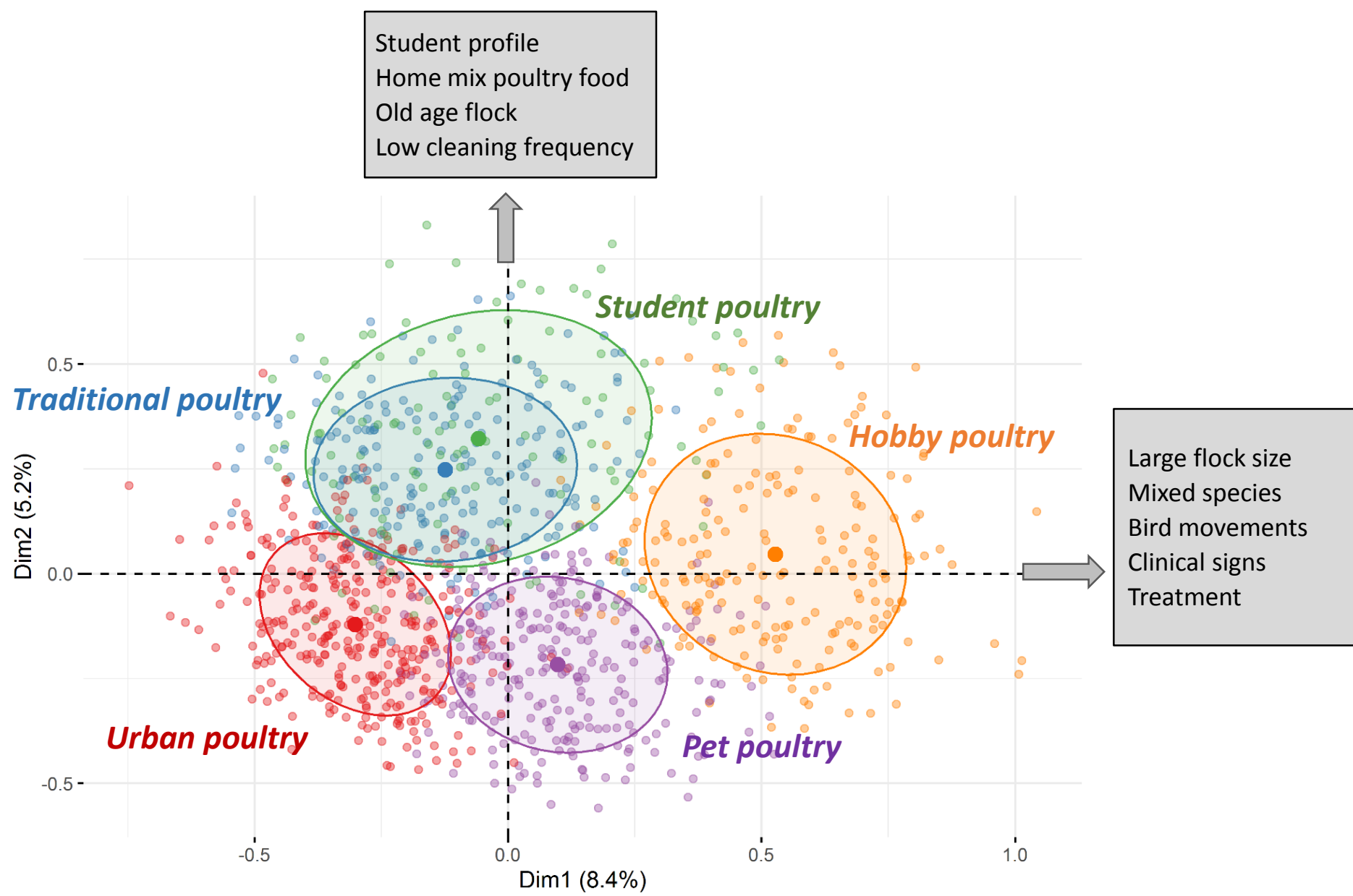


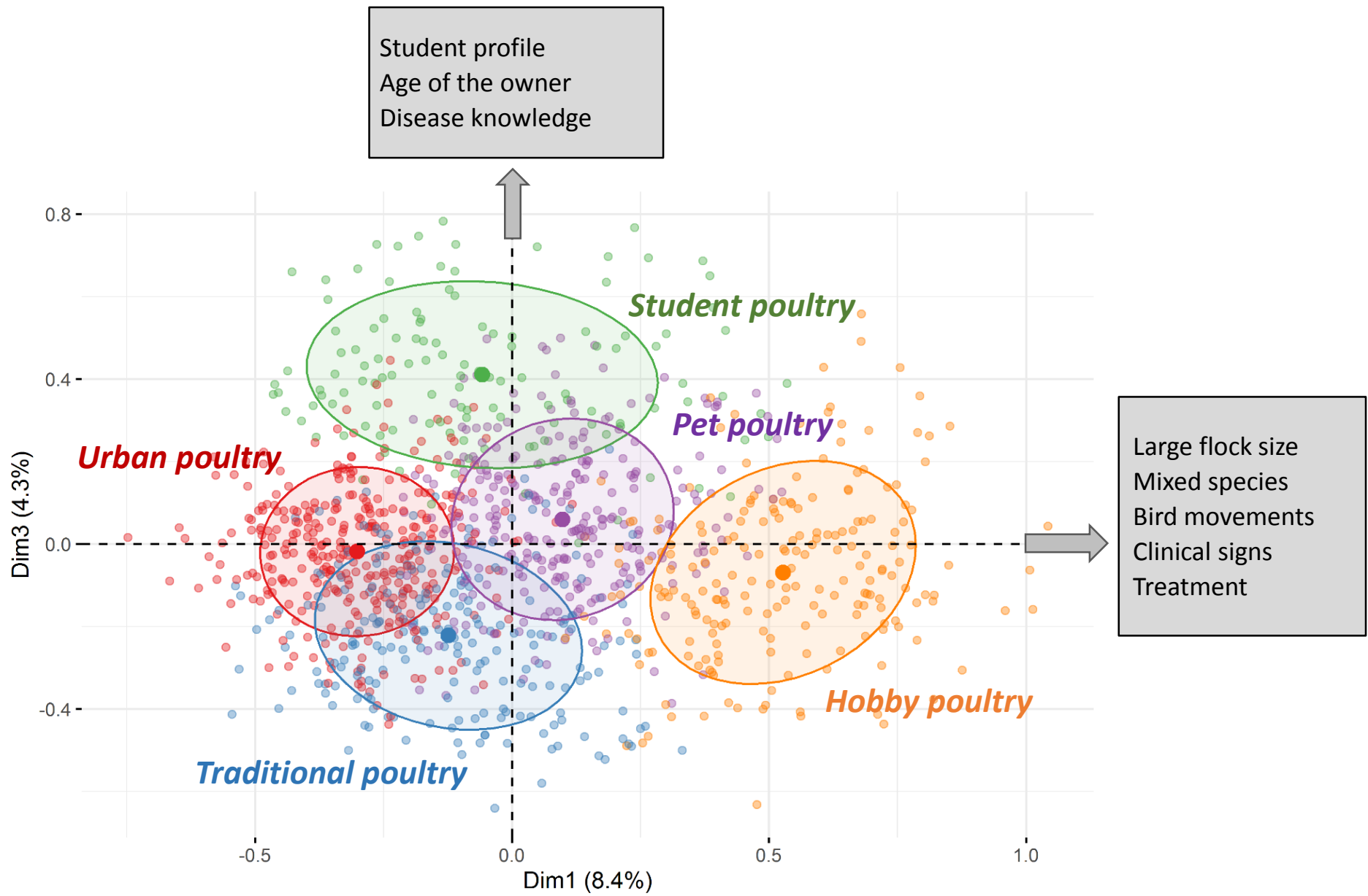












Student profile  
Age of the owner  
Disease knowledge

*Student poultry*

*Pet poultry*

*Urban poultry*

*Traditional poultry*

*Hobby poultry*

Large flock size  
Mixed species  
Bird movements  
Clinical signs  
Treatment