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Authors: Broyer, Joël, and Bourguemestre, François

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Common pochard *Aythya ferina* breeding density and fishpond management in central France

Joël Broyer and François Bourguemestre

J. Broyer (https://orcid.org/0000-0002-5333-4229) ✉ (joel.broyer@ofb.gouv.fr), Office Français de la Biodiversité (OFB), DRAS-Pôle ECLA, Station de la Dombes, Montfort, FR-01330 Birieux, France. – F. Bourguemestre, Fédération des Chasseurs de l'Indre, Châteauroux, France.

Fishponds constitute a major breeding habitat for the common pochard *Aythya ferina* in Europe. This study explored possible causes of its recent decline, in describing the consequences of diverse pond management options in Brenne, central France. Pair density and the brood:pair ratio were described in a pond sample under varying management practices, in the early 2000s and, again, a decade later. The influence of pond management on these variables was studied by model comparisons. In the early 2000s, 69.5% of the studied ponds were fertilized by fish farmers. Higher pochard pair densities were observed in those with artificial carp feeding and the brood:pair ratio was positively related to fish biomass density, provided that pair density was not too high. A decade later, only 25% of studied ponds remained fertilized. Pochard pair density was positively correlated with fish biomass density. But lower brood:pair ratios were recorded in ponds with artificial carp feeding, due to the fact that higher pair density there did not lead to increased brood density. Between the two study periods, the pair number remained stable in the sample but the brood:pair ratio decreased, from 0.84 to 0.71. Our results support the idea that habitat conditions that enable high fish productivity were also attractive for pochard pairs. They suggest the hypothesis that pond fertilization for enhancing primary productivity and, thereby, fish biomass, may also favour pochard breeding success. We must however bear in mind that, even with active fish farming management, fish biomass density in French fishponds remains usually moderate when compared to those in central Europe. The study did not reveal any effect of hunting management since waterfowl feeding, predator control or mallard release did not significantly influence either pond use by pochard pairs or the brood:pair ratio.

Keywords: brood:pair ratio, common pochard, fishpond, pair density, pond management

The common pochard *Aythya ferina* provides a good example of successful adaptation to a man-made habitat: the fishpond system. Formerly an infrequent breeder in this ecosystem, this species settled at the end of the 19th century in pond complexes of southern Bohemia, and at the beginning of the 20th century in eastern France and southern Moravia, several decades before a significant increase in fish farming productivity (Bauer and Glutz von Blotzheim 1969). This large-scale extension of breeding range toward south-western Europe could have been triggered by changes in the rainfall regime throughout the species' initial strongholds (Formosof 1934, Kalela 1940, 1949). Later only, local population growth in central Russia in the 1960s, in Byelorussia in the 1980s, or the quadrupling of wintering numbers in eastern Germany from the 1960s to the 1980s, were attributed to aquaculture progress in European pond systems (Sukhanova 1996, Rutschke and Liebherr 1998, Kozulin et al. 2002). But from the end of the 1970s, a long-term decline began in many areas. In the Czech republic, carp stocking in ponds strongly increased at the expense of pochard numbers, breeding adults (Pykal and Janda 1994) or broods (Musil et al. 1997). In Byelorussia however, a 55% decrease of the pochard population between 1990–1995 and 1999–2001 was explained by an economic crisis in fish farming which led to a reduction in the use of artificial carp feeding (Kozulin et al. 2002).

Fox et al. (2016) described the pochard decline over the last 30 years in a wide proportion of Europe and highlighted the urgent need of further information on the key factors affecting its abundance and breeding success. Fishponds nowadays constitute one of the most commonly used habitats in many countries (France, Germany, Poland, Czech Republic, …) and fish farming management is likely to affect positively or negatively pochard breeding conditions. Aquaculture may be detrimental to water birds through the competition with fish for food resources or the impacts of

Table 1. Pond number in studied samples, with presence or absence of fertilization with nitrogen (N), phosphorus (P), cow manure (M), of liming (L), carp feeding (CF), waterfowl feeding (WF), predator control (PC), mallard *Anas platyrhynchos* release (MR), in Brenne (2000–2003 and 2009–2014).

		N	P	M	L	CF	WF	PC	MR
2000–2003	absence	22	53	41	34	19	33	11	48
	presence	37	6	18	25	40	26	48	11
2009–2014	absence	41	51	49	46	20	28	12	42
	presence	11	1	3	6	32	24	40	10

Cyprinids on water turbidity and aquatic vegetation (Crivelli 1983, Musil 2006, Haas et al. 2007). But after fish farming abandonment, ponds may become less attractive to pochard pairs (Broyer et al. 2015, 2016, 2017). It is therefore important to understand how fish farming management may interfere with pochard's habitat selection and reproductive results. This study attempted to explore the paradox and the limit of the coexistence of some of the most important populations in Europe with high fish biomass density in fishpond complexes. We observed pochard response to varying pond management, by fish farmers but also by waterfowl hunters, in Brenne (central France). Fish farming in this region is neither too intensive nor threatened by massive on-going abandonment. There is nevertheless a wide gradient of habitat conditions, with or without pond fertilization or liming, artificial carp feeding, predator control, waterfowl feeding or release for game purposes. Our objective was to identify the most influential drivers of pochard breeding at the pond level and to describe the consequence of recent changes in pond management.

Method

Pond selection

The study region (46°49′N, 01°13′E) is one of the most important breeding area for aquatic birds in France. In Brenne, more than 1000 ponds, commonly used for fish farming and waterfowl game, are mainly surrounded by a mosaic of permanent meadows and arable land. Fish biomass density, mainly carp *Cyprinus carpio* (approximately 60% of total fish biomass), varies usually between 150 and 400 kg ha^{-1} (biomass harvested in winter).

The objective was not to describe the regional situation in a representative pond sample but to better understand some consequences of fish farming and game management practices. In the selection of the pond sample, we therefore attempted to limit the interference of extra environmental variables likely to obscure the effects of our variables of interest. As a rule, we tended to avoid ponds that were too isolated, very small, or with close surroundings obviously affected by direct human disturbance. We selected 59 ponds in 2000–2003 (n = 4 years) and 52 in 2009–2010–2012–2014 (n = 4 years), among which 10 were studied only in the first period and three only in the second one (49 ponds were studied in both periods). All these ponds were potentially favourable for duck nesting, in particular with presence of littoral emergent vegetation, surrounded by a typical terrestrial environment with grassland, arable land, moor with heather broom or common gorse. They were scattered throughout the study region. Pochard abundance in a given pond is likely to be influenced by habitat quality in one or several nearby water bodies. The absence of precise data, for a high number of neighbouring ponds, made this variable difficult to control. There are however no clear patches of pochard concentration in Brenne and pond management varies similarly all over the study region.

Mean surface areas were 9.6 ha ± 7.6 SD in 2000–2003, 9.8 ha ± 7.8 SD in 2009–2014. Pond management and pochard abundance were described for all selected ponds in the first period. In the second period, pond management was studied in the complete sample but pochard abundance was described in 49 ponds, among which 48 were also monitored in 2000–2003.

Data collection

Pond management

Data on pond management were collected by questioning fish farmers and land owners for the periods 2000–2003 and 2009–2014. Pond management may influence pochard abundance through a competition with fish or with ducks released for hunting purposes, through altered trophic conditions (extra food artificially provided, enhanced primary productivity), and through a limitation of predation. We selected six variables for fish farming: fish biomass density (FB, from total fish harvest after pond emptying), presence/absence of annual fertilization by nitrogen (N, usually 20–35 kg ha^{-1}), phosphorus (P) or cow manure (M, approximately 500 kg ha^{-1}), of liming (L), of artificial carp feeding (CF, corn flour or crushed

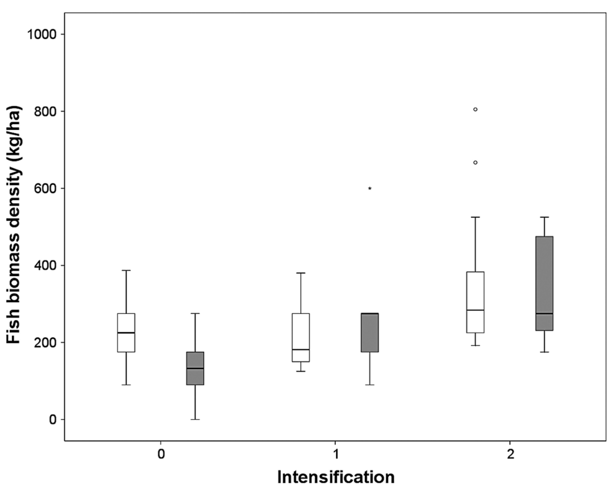

Figure 1. Variation of fish biomass density (white: 2000–2003, grey: 2009–2014) with fish farming intensification (0 = without fertilization and carp feeding, 1 = with carp feeding only, 2 = with fertilization and carp feeding).

Table 2. Model selection analysis of the influence on pochard *Aythya ferina* pair density, of pond fertilization with nitrogen (N) or cow manure (M), of liming (L), carp feeding (CF), fish biomass density (FB), predator control (PC), waterfowl feeding (WF), mallard *Anas platyrhynchos* release (MR) and pond surface area (S) (Brenne 2000–2003). (*) Corresponds to the null model.

Models	n	k	AIC	ΔAIC	w
CF + FB	53	4	261.91	0	0.59
CF	53	3	264.53	2.62	0.16
CF + WF	53	4	265.58	3.67	0.09
CF + WF + S	53	5	266.54	4.63	0.06
(*)	53	2	267.09	5.18	0.04
L + CF + WF + S	53	6	267.93	6.02	0.03
L + CF + WF + MR + S	53	7	269.42	7.51	0.01
L + CF + WF + PC + MR + S	53	8	271.12	9.21	0.01
M + L + CF + WF + PC + MR + S	53	9	273.06	11.15	0.00
N + L + CF + WF + PC + MR + S	53	9	273.09	11.18	0.00

Variables	Estimate	SE	t	p
Intercept	3.1301	0.9192	3.405	0.001
CF	1.8551	0.8230	2.230	0.030
FB	–0.0026	0.0029	–0.886	0.38

grain spread in water between April and September) and three variables describing management by hunters for enhancing waterfowl reproduction: presence/absence of predation control (PC, active destruction of nest predators : *Corvus corone*, *Vulpes vulpes*, *Martes martes* or *M. foina*, *Rattus norvegicus*), of waterfowl feeding (WF, grain spread near pond edges from the summertime), of release of artificially bred mallard *Anas platyrhynchos* (MR). Phosphorus application was infrequent and not taken into account in the analysis.

Pochard pair and brood counts

Each year (n = 4 for each period), Pochard adults and broods were censused every week from mid-April to the end of July, by one unique comprehensive, very slow, scanning of all the pond area with a telescope ×40. Observations were limited to mornings and late afternoons to avoid the hottest daily period when birds may search for a shelter within vegetation cover. The time spent on each pond was proportional to the surface area to be surveyed (scan length) and to the abundance of aquatic vegetation likely to constitute visual obstacles (scan slowness). Pairs, isolated adults and groups were censused apart and brood size and age were systematically recorded.

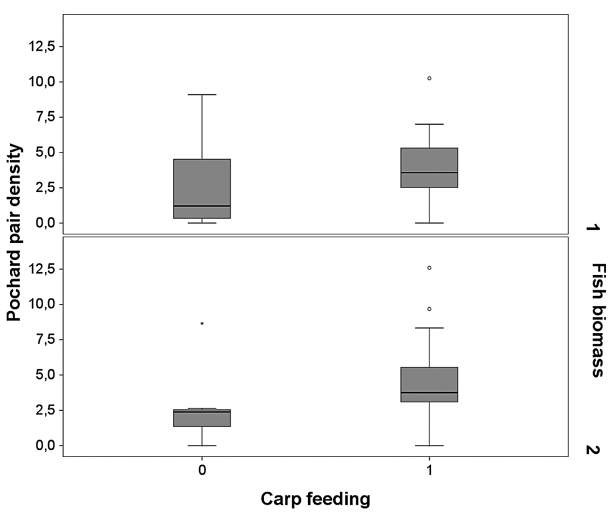

Figure 2. Variation of pochard *Aythya ferina* pair density in 2000–2003 with the presence/absence of carp feeding (CF), when fish biomass density FB is $< 237\,kg\,ha^{-1}$ (the mean value in the sample) (1) or FB $> 237\,kg\,ha^{-1}$ (2). (CF 0 and FB 1: n = 12; CF 0 and FB 2: n = 7; CF 1 and FB 1: n = 15; CF 1 and FB 2: n = 25).

Pair density derived from adult weekly counts can be considered as an approximation of absolute breeding pair number per unit area but, considering that breeding pairs usually restrict their activity during the pre-nesting, laying and early incubation periods (Sowls 1955), the level of error may be inconsequential for our research (Rotella et al. 1995). For each weekly count in each pond, the observed number of pairs was added either to lone females or to males alone or in small groups (< 5). The highest total was retained. As a rule, the number of pairs per pond corresponded to the highest number recorded at least three times between 15 April and 25 May. Each year, brood number per pond was the number of different broods ≤ 4-week-old observed at least once. Brood age and size were used to discern new broods from those already observed in the same pond in preceding weeks. Of course, we cannot ascertain that pairs assigned by this method to a given pond eventually nested there, or that observed broods actually hatched in this pond. For each pond, pair and brood number per pond corresponded to the average number in each period. For comparing pair abundance across ponds of different sizes, we analyzed beforehand the linear relationship between pond surface area and the mean values in the period 2000–2003 of: 1) pair number, 2) pair density (pair number/surface area), 3) pair number divided by the square root of surface area. Only pair density did not vary with pond surface area ($t = 0.901$, $p = 0.37$) and was therefore retained for studying the variation in pair abundance with pond management. Because brood number per pond was strongly correlated with pair number (first period: $F = 18.256$, $p < 0.001$; second period: $F = 79.596$, $p < 0.001$) and since ponds may attract broods coming from other water bodies, we decided to focus on the brood number independently of pair abundance, with the brood:pair ratio. This index was likely to describe the cumulative effect of nesting success and possible pond attractiveness for broods hatched in neighbouring ponds.

Table 3. Model selection analysis of the influence on pochard *Aythya ferina* pair density, of pond fertilization with nitrogen (N) or cow manure (M), of liming (L), carp feeding (CF), fish biomass density (FB), predator control (PC), waterfowl feeding (WF), mallard *Anas platyrhynchos* release (MR) and pond surface area (S) (Brenne 2009–2010–2012–2014). (*) Corresponds to the null model.

FB	41	3	191.43	0	0.36
M + FB	41	4	192.34	0.91	0.23
M	41	3	193.70	2.27	0.12
M + CF	41	3	194.28	2.85	0.09
(*)	41	2	194.47	3.04	0.08
M + CF + S	41	4	194.87	3.44	0.07
M + CF + MR + S	41	5	196.39	4.96	0.03
M + CF + WF + MR + S	41	6	197.52	6.09	0.02
M + L + CF + WF + MR + S	41	7	199.31	7.88	0.01
N + L + CF + WF + MR + S	41	8	201.53	10.10	0.00
N + L + CF + WF + PC + MR + S	41	8	203.35	11.92	0.00
Variables	Estimate	SE	t	p	
Intercept	1.8609	0.6883	2.704	0.010	
FB	0.0061	0.0027	2.259	0.029	

Data analysis

We first examined the observed changes, between the two study periods, in pond management and in pochard breeding. Because important changes in fish farming were described, likely to affect globally the pochard population in Brenne, the influence of pond management on pochard pair density and on the brood:pair ratio was studied separately for each study period. We used GLMs with a Gaussian distribution of error. Correlated variables (FB with N in 2000–2003, FB with N and MR in 2009–2014: $p < 0.01$) were not included in the same model. The best models were selected by Akaike's information criterion (AIC), retaining the models with the lowest AIC values ($\Delta AIC < 2$) (Burnham and Anderson 2002) by means of R ver. 3.0.3 software. Starting with the complete model, we used a step by step selection by removing the least influential variable (with the highest p-value), as long as the AIC value was improved. In case of more than one model within $\Delta AIC < 2$, these models were averaged (package MuMIn) so as to identify the statistically significant variables (estimates with confidence intervals that did not encompass zero).

In diving ducks, competition with fish is likely to affect duckling survival (Giles 1994). In Brenne, pochard brood size decreases from 4.7 chicks on average immediately after hatch to 3.8 at the age of two weeks and remains stable later on (Broyer 2002). For each pond, we therefore computed the mean size of broods which were observed at the age of two weeks. This method however did not allow us to take into account brood size = 0. The relationship with fish biomass density was investigated through simple and quadratic regressions.

Results

Pond management

The collected information indicated substantial differences in pond management between 2002 and 2013. The most striking change was the decreasing use by fish farmers of fertilizers (N, P, manure) and liming (Table 1). The proportion of ponds without any fertilization increased from 30.5% in 2002 to 75.0% in 2013. However, fish was still artificially fed in 61.5% in 2013 versus 67.8% in 2002. As a result, fish biomass density (FB) moderately decreased from $276 \pm 136\,kg\,ha^{-1}$ to 217 ± 133. FB was lower in 2013 in particular in ponds without fertilization and carp feeding: 127 ± 85 in 2013 versus $226 \pm 80\,kg\,ha^{-1}$ in 2002 (Fig. 1). This probably reflected a progressive loss of interest for low-intensity fish farming without active management. Game management (waterfowl feeding, predator control, mallard release) remained virtually unchanged (Table 1).

Pochard demographic trend

Pair and brood number per pond was 3.2 ± 2.7 SD and 2.6 ± 3.2 SD respectively in 2000–2003 (n = 59 ponds) and 3.1 ± 3.6 SD and 2.1 ± 2.9 SD in 2009–2014 (n = 49 ponds). Changes over time may be described in a subsample of 48 ponds monitored during each of the two study periods. In total, these ponds retained annually 146.0 potentially breeding pairs on average during the period 2000–2003 versus 148.0 during the years 2009, 2010, 2012 and 2014. Brood number however decreased from 122.1 to 105.6 over the

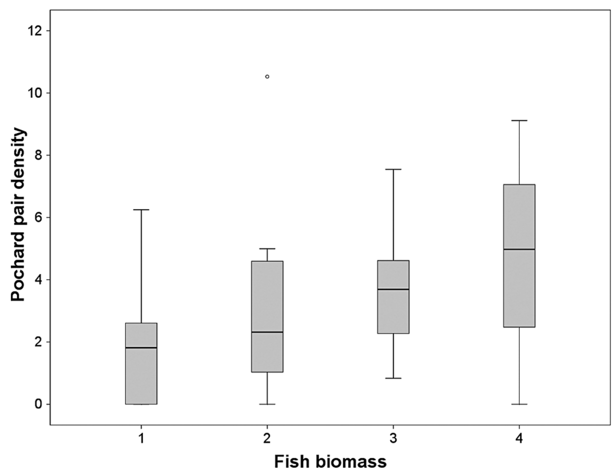

Figure 3. Variation of pochard *Aythya ferina* pair density in 2009–2014 with fish biomass density (1: < $100\,kg\,ha^{-1}$, 2: 100–$200\,kg\,ha^{-1}$, 3: 200–$300\,kg\,ha^{-1}$, 4: > $300\,kg\,ha^{-1}$).

Table 4. Model selection analysis of the influence on pochard *Aythya ferina* brood:pair ratio, of pond fertilization with nitrogen (N) or cow manure (M), of liming (L), carp feeding (CF), fish biomass density (FB), predator control (PC), waterfowl feeding (WF), mallard *Anas platyrhynchos* release (MR), pochard pair density (PD) and pond surface area (S). (*) Corresponds to the null model (Brenne 2000–2003).

Models	n	k	AIC	ΔAIC	w
FB + PD	53	4	218.49	0	0.71
FB	53	3	221.58	3.09	0.15
M + FB	53	4	222.26	3.77	0.11
M + L + WF	53	5	228.13	9.64	0.01
M + L	53	4	228.80	10.31	0.00
PD	53	3	228.92	10.43	0.00
M + L + WF + S	53	6	229.49	11.00	0.00
M	53	3	229.78	11.29	0.00
M + L + CF + WF + S	53	7	230.46	11.97	0.00
M + L + CF + WF + PS + S	53	8	232.00	13.51	0.00
N + L + CF + WF + PC + S	53	8	232.43	13.94	0.00
(*)	53	2	232.76	14.27	0.00
M + L + CF + WF + PC + MR + S	53	9	234.21	15.72	0.00
Variables	**Estimate**	**SE**	**t**	**p**	
Intercept	0.4561	0.9414	0.484	0.63	
FB	0.0070	0.0024	2.959	0.0049	
PD	−0.2755	0.1228	−2.244	0.030	

same time. At the sample level, the brood:pair ratio therefore was 0.84 in the first period and 0.71 in the second one.

Influence of pond management on pair density

According to the selected model, pochard pair density in 2000–2003 was mainly influenced, positively by artificial carp feeding, and negatively by fish biomass density. But CF only was statistically significant (Table 2, Fig. 2).

In 2009–2014, two models, including FB or FB+M, were within $\Delta AIC < 2$ (Table 3). After model averaging, only fish biomass density was (positively) significant, with $\beta = +0.00340$ and $SE = 0.00164$ (Fig. 3).

Influence of pond management on the brood:pair ratio

In 2000–2003, the best model included FB and PD (Table 4). The brood:pair ratio increased with fish biomass

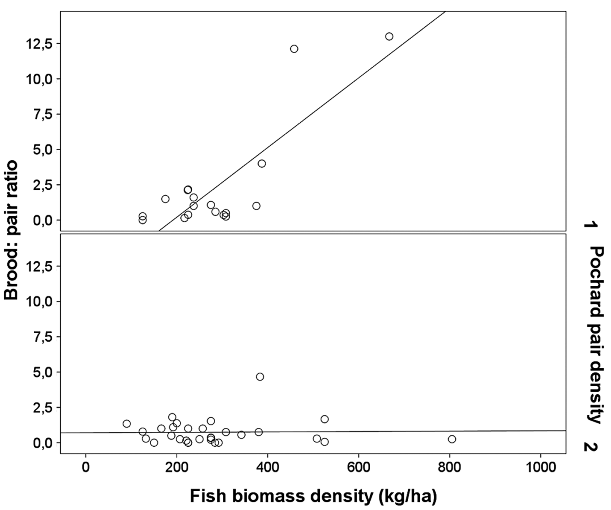

Figure 4. Variation in the pochard *Aythya ferina* brood:pair ratio with fish biomass density, when pair density is lower than 3.1/10 ha (the mean value in the sample) (1) or higher than 3.1/10 ha (2).

density and decreased with pochard density. Ponds most favourable to pochard nesting success and/or for attracting broods were those in which habitat conditions were also favourable for fish production, provided that pochard density was low enough (Fig. 4).

In 2009–2014, five models were within $\Delta AIC < 2$, including in total five variables (CF, S, L, PC, N) (Table 5). After model averaging, we found that only a negative influence of carp feeding was statistically significant ($\beta = -0.7547$, $SE = 0.2604$). The brood:pair ratio was comparatively low in ponds with carp feeding (Fig. 5). Brood abundance however was identical with or without carp feeding (2.1 ± 2.2 SD per 10 ha in both pond categories). In fact, carp feeding seemed to attract more pochard pairs (3.6 ± 2.2 SD per 10 ha (n = 25 ponds) versus 2.5 ± 2.9 SD (n = 16)) but without positive effect on brood abundance.

Brood size and fish biomass density

The size of two-week-old broods in 2009–2014 varied with fish biomass density according to a quadratic function ($F = 3.593$, $p = 0.04$). Brood size increased with FB up to ca 300 kg ha^{-1}, and tended to decrease with FB >500 kg ha^{-1} (but in two ponds only) (Fig. 6). However, brood size and FB were not related in the early 2000s ($p > 0.9$). This difference may be linked to the fact that fertilization or carp feeding were implemented in 57% of the ponds with low FB (< 200 kg ha^{-1}) in the first period (pochard brood size = 3.5 ± 1.4 SD) and only in 33% in the second one (brood size = 2.5 ± 0.9 SD).

Discussion

Pochard pair abundance in French fishponds may depend on diverse environmental variables, especially the availability of invertebrate-prey in pond sediment (Broyer and Calenge 2010), which could theoretically depend on pond primary productivity. In this study, their distribution within the pond sample was linked to habitat conditions allowing

Table 5. Model selection analysis of the influence on pochard *Aythya ferina* brood:pair ratio, of pond fertilization with nitrogen (N) or cow manure (M), of liming (L), carp feeding (CF), fish biomass density (FB), predator control (PC), waterfowl feeding (WF), mallard *Anas platyrhynchos* release (MR), pochard pair density (PD) and pond surface area (S). (*) Corresponds to the null model (Brenne 2009–2010–2012–2014).

Models	n	k	AIC	ΔAIC	w
CF+S	41	4	81.944	0	0.27
CF+S+L	41	5	82.324	0.38	0.22
CF+S+L+PC	41	6	82.962	1.02	0.16
CF	41	3	83.102	1.16	0.15
N+L+CF+PC+S	41	7	83.853	1.91	0.10
CF+S+PD+FB	41	6	84.104	2.16	0.09
N+L+CF+NF+PC+S	41	8	85.126	3.18	0.05
N+L+CF+WF+PC+S+MR	41	2	85.681	3.74	0.04
PD	41	3	86.668	4.72	0.00
(*)	41	2	86.963	5.02	0.00

Variables	Estimate	SE	t	p
Intercept	0.9785	0.2276	4.299	0.0001
CF	−0.7742	0.2630	−2.944	0.006
S	0.0250	0.0144	1.739	0.091

high fish production. In the early 2000s, lower pair density was recorded in case of absence of artificial carp feeding. Similarly after a reduction of carp feeding in Byelorussia, the pochard population decreased in the second half of the 1990s (Kozulin et al. 2002). This suggests either that pochard adults were attracted by the food spread for carps, usually away from the pond edges, or that artificially fed carps, even at high biomass density, were not in harsh competition with pochards for invertebrate-prey. The cessation of pond fertilization by many fish farmers in Brenne between 2000–2003 and 2009–2014 did not affect total pochard pair number in the sample, but pairs were less abundant and the size of two-week-old broods was lower in ponds with low fish biomass density. This result seems to be in contradiction with commonly reported situations where waterfowl abundance was negatively affected by fish biomass (Bouffard and Hanson 1997). This could be explained by the hypothesis that low fish biomass here was a symptom of lower primary productivity in the aquatic ecosystem, similarly detrimental to both fish and waterfowl.

While fertilization was abandoned by a majority of fish farmers, the pochard population in the sample, although stable, produced less broods. In the early 2000s, the brood:pair ratio was higher in ponds with high fish biomass. Again, this could theoretically express positive consequences on pochard reproductive results or brood attractiveness of trophic conditions which were also favourable to Cyprinids. Moreover, the pochard brood:pair ratio seemed to be density-dependent, decreasing as pair density increased. Density-dependent breeding success was observed in oligotrophic boreal lakes where, with higher pair density, mallards *Anas platyrhynchos* produced fewer broods and duckling survival was higher, so that the number of fledged ducklings was not affected (Pöysä et al. 2010). A decade later in Brenne, higher pair density in ponds with artificial carp feeding did not lead to proportionally increased brood density. The brood:pair ratio was lower there because brood density was not enhanced despite the fact that more pairs have been observed. In French fishponds, the diving duck brood:pair ratio is mainly influenced by pond fertilization (Broyer and Calenge 2010).

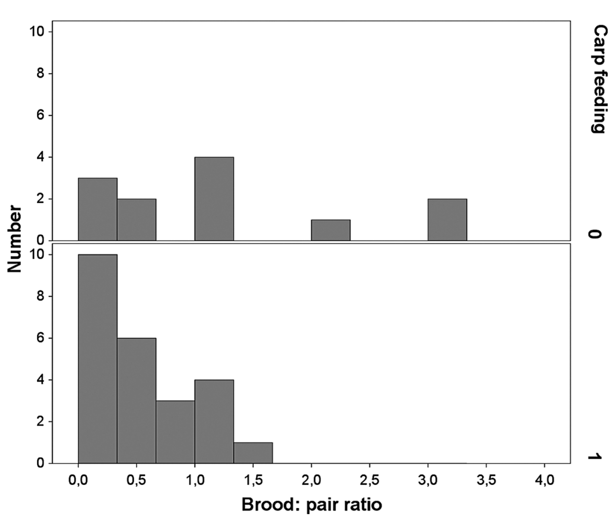

Figure 5. Variation in the brood:pair ratio in ponds with and without artificial carp feeding.

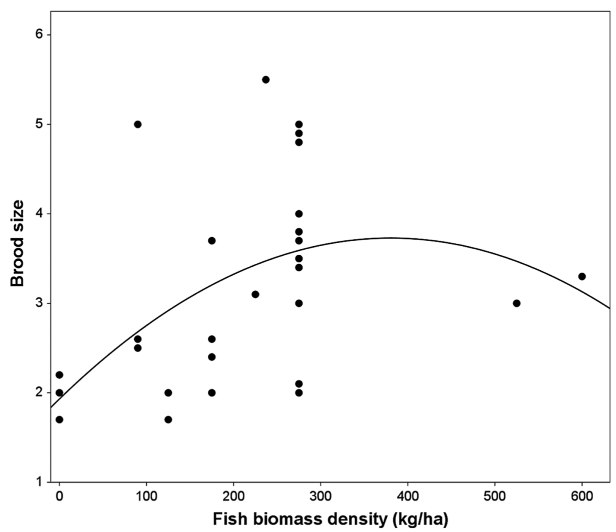

Figure 6. Quadratic regression curve of pochard brood size and fish biomass density in Brenne fishponds (2009–2010–2012–2014).

In this study indeed, the ratio in the sample decreased from 0.84 to 0.71 between the two periods, along with a decreasing use of fertilizer.

Whereas too high a fish biomass was often identified as a limiting factor for water birds in fishponds (Musil 2006, Haas et al. 2007), a lack of active management by fish farmers seems also to be detrimental to pochard breeding in Sologne (central France), where this species tends to avoid ponds ten years after fish farming cessation (Broyer et al. 2018). The pochard could illustrate a general theory according to which the response of biodiversity to productivity in aquatic ecosystems is likely to follow a hump-shaped pattern (Dodson et al. 2000, Mittelbach et al. 2001), with optimal results in intermediate situations. This pattern indeed seems to be confirmed in Brenne where pochard two-week-old brood size increased with growing fish biomass up to ca 300 kg ha^{-1} and seemed to decrease at higher biomass density.

In conclusion, pochard pairs in Brenne were attracted by habitat conditions most favourable to fish production even though the local population was, for the moment, not affected by the recent interruption of pond fertilization by many fish farmers. Breeding outputs however were decreasing despite a negative trend in fish biomass density. In addition to fish farming abandonment or increasing fish stocking, changes in pond management leading potentially to lower primary productivity could therefore be one of the possible explanations to the recent decline of the pochard in Europe. This study however did not reveal any effect of hunting management since waterfowl feeding, predator control or mallard release did not significantly influence either pond use by pochard pairs or the brood:pair ratio. Another putative cause for decreasing brood:pair ratio in French fishponds could be the impact of the coypu *Myocastor coypus* on vegetated areas available along pond edges for pochard nesting and the correlative consequences on nest predation (Broyer unpubl.).

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