

1 **Chronic boat noise does not alter the fitness of *Daphnia***
2 ***magna***

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12

13 **Abstract**

14 Ecotoxicological studies mainly focus on chemical pollution, however, since past decades,
15 there has been a growing interest for acoustic pollution. Previous studies on underwater acoustic
16 pollution showed that noise affects vertebrates' behaviour, like fish and marine mammals.
17 However, little is known about invertebrates and there is a huge lack concerning zooplankton
18 species which are widely used as bioindicators in chemical pollution. Consequently, it could be
19 useful to assess the impact of noise in terms of fitness (survival and fecundity). Here, isolated
20 water fleas, *Daphnia magna*, were reared from birth to death in the presence or absence of
21 motorboat noises. Effects on lifespan and clonal offspring production (e.g., clutch size, number
22 of offspring produced along life) were measured and chronic exposure to boat noise did not
23 affect *Daphnia's* fitness. The spectral and temporal features of the sounds could explain the
24 results. This study highlights the importance to integrate noise pollution into ecotoxicological
25 research to understand, and prevent, human impacts on communities.

26 **Keyword:** *Daphnia magna*, Acoustic pollution, Boat noise, Fitness, Survival, Reproduction.

27

28 **1. Introduction**

29 Freshwater ecosystems are vulnerable to many types of anthropogenic pollution (e.g.,
30 chemicals, light, radioactivity, nanopollution, sounds) (see for instance Longcore & Rich, 2004;
31 André et al., 2011; Song et al., 2020; Jan et al., 2022) but the most documented to date remain
32 chemical pollutions (e.g., industrial effluents, urban waste, pesticides, drugs) (Truhaut, 1977;
33 Villeneuve & Garcia-Reyero, 2011). Toxicological studies have documented, in a
34 comprehensive and accurate way, the effects of different types of pollutants (e.g., ion, heavy
35 metals, drugs), exposure durations (acute or chronic), intensities (e.g., median Lethal Dose
36 LD₅₀), and the interactions between them and with environmental parameters (temperature,
37 acidity, humidity, etc.). Those results have contributed to the general knowledge allowing the
38 evaluation of other types of pollution.

39 This study focuses on acoustic – or noise – pollution described as a pervasive and
40 omnipresent pollutant found in all ecosystems (terrestrial, marine, and freshwater) (Shannon et
41 al., 2016; Popper & Hawkins, 2019; Kunc & Schmidt, 2019), and which represents a growing
42 research topic (Williams et al., 2015; Slabbekoorn, 2019). Specifically, this study focuses on
43 the effect of boat traffic, an important source of noise likely to threaten aquatic systems
44 (Rountree et al., 2020; Duarte et al., 2021). Moreover, studies on noise pollution have mainly
45 focused on behaviour (Richardson et al., 1985; Duarte et al., 2021). Thus, contrary to many
46 ecotoxicological studies since Truhaut (1977), it remains a gap in understanding how noise
47 pollution affects individual fitness, i.e. survival and fecundity (Francis & Barber, 2013; Read
48 et al., 2014).

49 Although the effects of noise on large invertebrates, such as decapods or bivalves, have
50 recently received substantial interest (see the reviews of Popper et al. (2001) and Solé et al.
51 (2023)), research largely neglected zooplanktonic invertebrates (Hawkins et al., 2015; Prosnier,

52 2022), despite their ecological importance and general use as bioindicators in ecotoxicology
53 (Parmar et al., 2016). Zooplankton do not possess hearing structures, however they present
54 mechanoreceptors that allow them to detect particle motion, the other component of a sound
55 with pressure (Gassie et al., 1993; Buskey et al., 2002). For instance, Gassie et al. (1993) found
56 that marine copepods (*Acartia fossae*) can detect water vibrations, and Buskey et al. (2002)
57 showed that vibrations can lead to an individual acceleration of *Acartia spp.*. Marine
58 zooplankton (e.g., copepods) exposed to acute airguns show a reduction of their survival
59 (McCauley et al., 2017; Fields et al., 2019; Vereide et al., 2023). *Chaoborus flavicans* larvae,
60 an important zooplankton predator, show more body rotations, interpreted as an anti-predatory
61 behaviour, when exposed to boat noise for the first time (Rojas et al., 2021). These works
62 highlight that noise could affect the fitness and behaviour of zooplankton species. However
63 long-term exposure has not been investigated yet except *D. magna* exposed to chronic
64 broadband noise, that showed a lower speed and surprisingly a higher fitness and (Prosnier,
65 Rojas, et al., 2022).

66 A particular acoustic parameter of noise is the temporal pattern that it can exhibit (Francis
67 & Barber, 2013) with chronic exposure at the one hand and acute exposure at the other (Duarte
68 et al., 2021). Chronic exposure means a continuous or intermittent, regular or random sound
69 (e.g., turbine, boat noise) whereas acute exposure represents a punctual sound (e.g., airgun)
70 (Nichols et al., 2015; McCauley et al., 2017). The spectral (i.e., sound level of each frequency)
71 and temporal patterns of noise are known to affect the behaviour and physiology of organisms
72 in different ways. For instance in underwater chronic noise studies, fish are more affected by a
73 random noise than by a continuous or regular one (Nichols et al., 2015). These results are
74 interpreted as an ability for vertebrates to habituate to some predictable long-term noise
75 exposition (Rojas et al., 2021). Consequently, this raises the question of whether some results
76 with unrealistic noise, as continuous broadband noise (Prosnier, Rojas, et al., 2022), could be

77 extrapolated to real situation where organisms are exposed to boat noise, thus exposed to
78 intermittent random noise (i.e., unpredictable) with high spectral variability.

79 The aim of this study was to investigate the effect of chronic exposure to motorboat noise
80 (intermittent and random noise with spectral variability) on the fitness of the water flea *Daphnia*
81 *magna*, a common zooplankton species widely used in ecotoxicology (Ebert, 2022). Previous
82 studies found no change in their mobility when exposed to acute noise (Sabet et al., 2015, 2019),
83 whereas prior experiment with chronic exposure to broadband noise (i.e., a continuous noise)
84 showed alterations in both fitness and behaviour (Prosnier, Rojas, et al., 2022). If arthropods
85 react as fish, then intermittent boat noises (i.e., unpredictable) should affect more individuals
86 than continuous broadband noise (i.e., predictable). Consequently, motorboat noise should
87 affect fitness of *D. magna*. No to negative effects are expected according to various chronic and
88 acute exposure experiments on invertebrates (Solé et al., 2023), but note that a positive effect
89 was found for *D. magna* chronically exposed to broadband noise (Prosnier, Rojas, et al., 2022).

90 **Material and Methods**

91 *1.1. Collection and maintenance of organisms*

92 *Daphnia magna* had been purchased from Aqualiment (Grand Est, France) and stored in a
93 20-L rearing aquarium, filled with aged tap water (physiochemical composition is available on
94 Zenodo repository (Prosnier et al., 2023)), for one month. They were reared at 18°C under a
95 12:12 light:dark cycle. *Daphnia magna* were fed, every two days, with 0.05g of algae (i.e.,
96 736 mJ) with a mix of 80% of *Arthrospira platensis* and 20% of *Aphanizomenon flos-aquae*
97 (Algo'nergy® Spiruline + Klamath).

98 1.2. Fecundity and mortality

99 Reproductive success and survival were measured during an experiment (similar as done in
100 Prosnier, Rojas, et al., 2022). Gravid *D. magna* were collected from the rearing aquarium and
101 isolated in 50 mL jars containing Volvic® water. Newborns (< 24h) were transferred

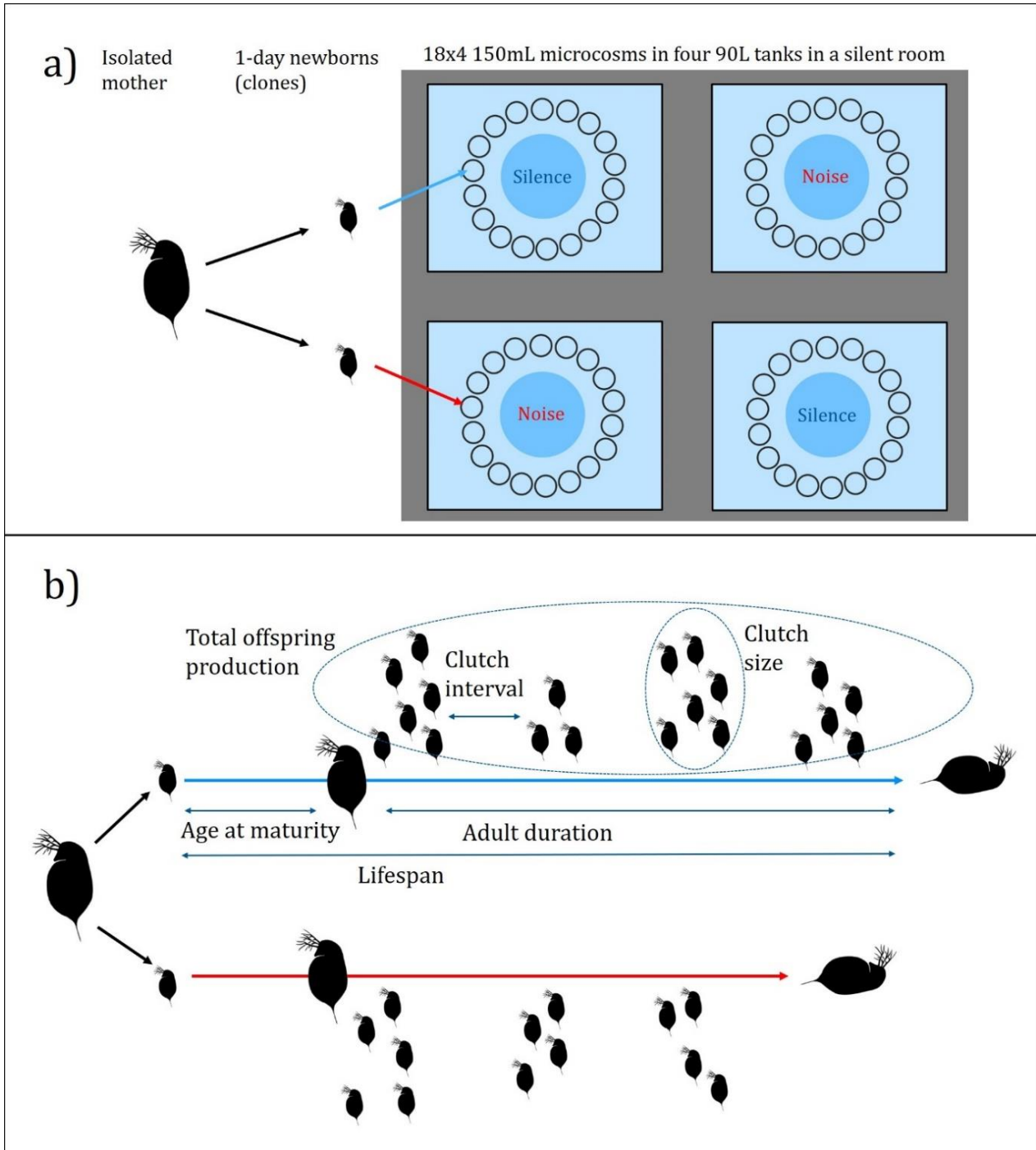


Figure 1. Setup. a) Experimental design. In the four tanks blue circles are loudspeakers, dark small circle are microcosms closed with net. b) Summary of all measures from birth to death of clonal individuals in the two treatments.

102 individually into 150-mL (5.6 x 8.6 cm) glass microcosm, closed with a 0.3-mm mesh tissue
103 allowing water flows and noise transmission (Fig. 1).

104 Eighteen glass microcosms were disposed at 20 cm of an underwater loudspeaker in four
105 150 L rectangular tanks (75 x 60 x 35 cm), filled with 90 L of aged tap water, at 20-22°C and
106 under a 12:12 light:dark cycle. Silence was broadcasted in the two control tanks and a daily
107 boat noise playlist (see below) used as treatment was broadcasted in the two other tanks. For
108 each *D. magna* mother, half of the newborns were exposed to the control treatment, and the
109 other half to the noise treatment, therefore individuals were clones in the two acoustic
110 conditions. Each day, survival and newborns production were controlled – if *D. magna*
111 spawned, offspring were counted and taken off. Every two days, individuals were fed with 2
112 mL of algae (1g/L), and water was changed once a week. During the eight first days of the
113 experiment (i.e., before the first hatching), dead *D. magna* were replaced by new newborns
114 (isolated mothers were maintained in 50 mL jars during this initial period to be able to initiate
115 new replicates with newborns) to increase the number of replicates. Experiments were
116 performed with a total of 115 juveniles (58 in control and 57 exposed to noise) coming from 25
117 mothers; almost half of the juveniles in each condition (26 in control and 23 in noise) reached
118 maturity. The experiment lasted 46 days, from the birth of the first individual to the death of
119 the last one (the oldest *D. magna* survived 39 days).

120 Based on daily survival and daily clutch, populational data was analysed using the Euler-
121 Lotka equation ($\sum f_x m_x e^{-rx} = 1$), with f_x the fecundity at age x , m_x the survival at age x , and
122 r the intrinsic rate of increase. This equation allows to calculate the reproductive output R_0
123 ($R_0 = \sum f_x m_x$), the generation time G_t ($G_t = \frac{\sum x f_x m_x}{\sum f_x m_x}$), and the intrinsic rate of increase r
124 ($r = \frac{\log R_0}{G_T}$) (Leung et al., 2007; Starke et al., 2021).

125 1.3. Acoustic treatments

126 *Daphnia magna* were exposed to two acoustic treatments (see Rojas et al. (2021) for more
 127 details): a repeated 1-h playlist without sound for the control (i.e., only the ambient noise), or
 128 boat noise for the treatment with a playlist including 15 recordings of motorboat sounds
 129 previously made in the Grangent lake (45°45'07.54"N, 4°25'56.47"E, Loire, France). Their
 130 intensity was modulated from 0 to -25 dB Re 1 μ Pa by 5 dB to create 75 sounds from 103 to
 131 150 dB Re 1 μ Pa – a naturally-occurring range of noise levels found in lakes (V. Médoc, pers.

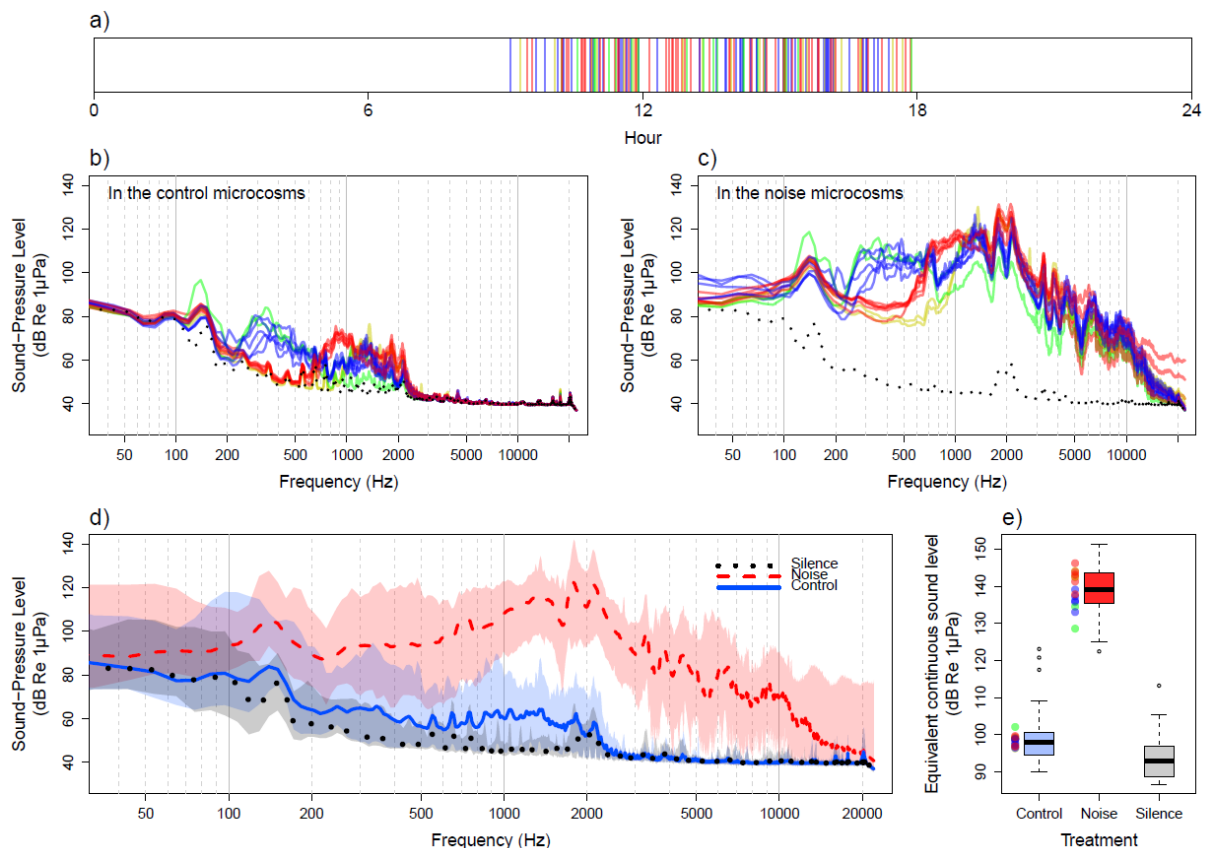


Figure 2. Acoustic treatments. a) 24-h temporal sequence of the broadcasted motorboat noises, from 9 a.m. to 6 p.m. Each vertical line represents a boat. b) Soundscapes of the control microcosms recorded in half microcosms with the records of the 15 boat sounds (solid lines), broadcasted at their maximal intensity in the noise tanks, and silence (dotted line). c) Soundscapes in the noise microcosms recorded in half of the microcosms during the broadcast of the 15 boat sounds at their maximal intensity (solid lines) and silence (dotted line). d) Spectra in half of the microcosms. Thick lines are means for control (full blue line) and noise treatment (dashed red line) during the 15 boat broadcasts at their maximal intensity, and during the silence period (dotted black line). Shaded areas delimit the min and max Sound-Pressure Level. e) Sound levels in half of the microcosms. Central bars represent the median, boxes the interquartile range, and dots the outliers (> 1.5 times the interquartile range). Coloured dots are the sound levels in control and noise microcosms during the 15 boat broadcasts at their maximal intensity. The four colours (red, yellow, green, blue) correspond to **four noise structure spectra that were visually determined (for instance red and yellow have low energy between 200 and 700 or 1000 Hz compared to green and blue boat noises).**

132 obs.) –, that were duplicated to obtain the total of 150 boat noises used in the experiment. Boat
133 noise playlist was broadcasted from 9 a.m. to 6 p.m. (Fig. 2a). Both playlists (stereo WAV files)
134 were generated using the software Adobe Audition 2020 (13.0.0.519, Adobe Systems Inc.,
135 Mountain View, CA, USA) and were played back using a Zoom® H4n recorder connected to
136 an amplifier (DynaVox® CS-PA 1MK), and an underwater loudspeaker UW30 (Electro
137 Voice®).

138 To check spectra and noise levels in both control and noise microcosms, recordings were
139 made (Fig. 2b-e) with a Zoom® H4n coupled to a hydrophone (Aquarian Audio H2A-HLR
140 Hydrophone, frequency response from 10 to 100 kHz) previously calibrated with a hydrophone
141 (8104, Brüel & Kjær, Naerum, Denmark; sensitivity -205 dB re. 1 V μPa^{-1} ; frequency
142 response from 0.1 Hz to 180 kHz) connected to a sound level meter (Bruël & Kjaer 2238
143 Mediator, Naerum, Denmark). Emitted boat noises were firstly corrected, using a one-third
144 octave graphic equalizer (with Adobe Audition 2020), to make their spectra closer to those of
145 the initial 15 boat noise spectrums (Fig. 2). Boat noises were re-recorded only in half of the
146 microcosms (in each tank) given that they were qualitatively and quantitatively similar due to
147 the symmetry of the setup and after controlling with a broadband noise (Prosnier, Rojas, et al.,
148 2022). Note that the playback of boat noise was perceived in the control microcosms with
149 intensities around 100 dB Re 1 μPa , which was almost comparable to the sound level during
150 the silence period (Fig. 2e) allowing to neglect noise transmission between the treatments.
151 Particle motion cannot be measured due to the absence of adequate equipment, despite its
152 importance for non-hearing species (Nedelec et al., 2016). However, Olivier et al. (2023)
153 showed that results can still be qualitatively relevant when based solely on sound pressure level.

154 1.4. Statistical analyses

155 Statistical analyses were performed using R (version 4.2.2) with a significant threshold at
156 5%. Data allowed to analyse separately the effects on mortality (death age and adult survival)
157 and fecundity (age at maturity, clutch frequency, mean clutch size, and daily clutch size). The
158 combination of mortality and fecundity was used as a proxy of fitness and quantified through
159 total offspring production. Data was also described at the population scale using the Euler-
160 Lotka equation (but without statistical analysis due to absence of populational replicates). A
161 survival analysis (Log-Rank test) was performed to compare survival (death age and adult
162 duration) and age at maturity (first clutch age) between the control and noise treatments. For
163 the fecundity parameters, only individuals that clutched at least one time (i.e., that reached
164 maturity) were considered in the analyses. Clutch frequency (i.e., mean time between two
165 clutches) and mean clutch size were analysed using linear mixed-effects model, with tanks as
166 random effect, thanks to the normal distribution of the data checked with a Shapiro test. The
167 effect of both noise and age on daily clutch size was analysed by a type-II analysis of variance,
168 completed with a pairwise Wilcoxon test between the treatments within each age. To test noise
169 effect on the total number of clutches and offspring along life a generalized linear mixed-effects
170 models was used, with tanks as random effect and a log function as the link function for Poisson
171 distribution.

172 2. Results

173 Chronic boat noise did not affect (Table A1) the survival of *D. magna* (p-value = 0.51, Fig.
174 3a) with a median survival of 4 days for the control and 5 days for the noise treatment. It did
175 not affect fecundity parameters, with clutch interval around 2.5 days (p-value = 0.24, Fig. 3b),
176 mean clutch size around 10 offspring (p-value = 0.74, Fig. 3c) and age at maturity around 8
177 days (p-value = 0.65). Daily clutch size was not influenced by noise (noise: p-value = 0.89,

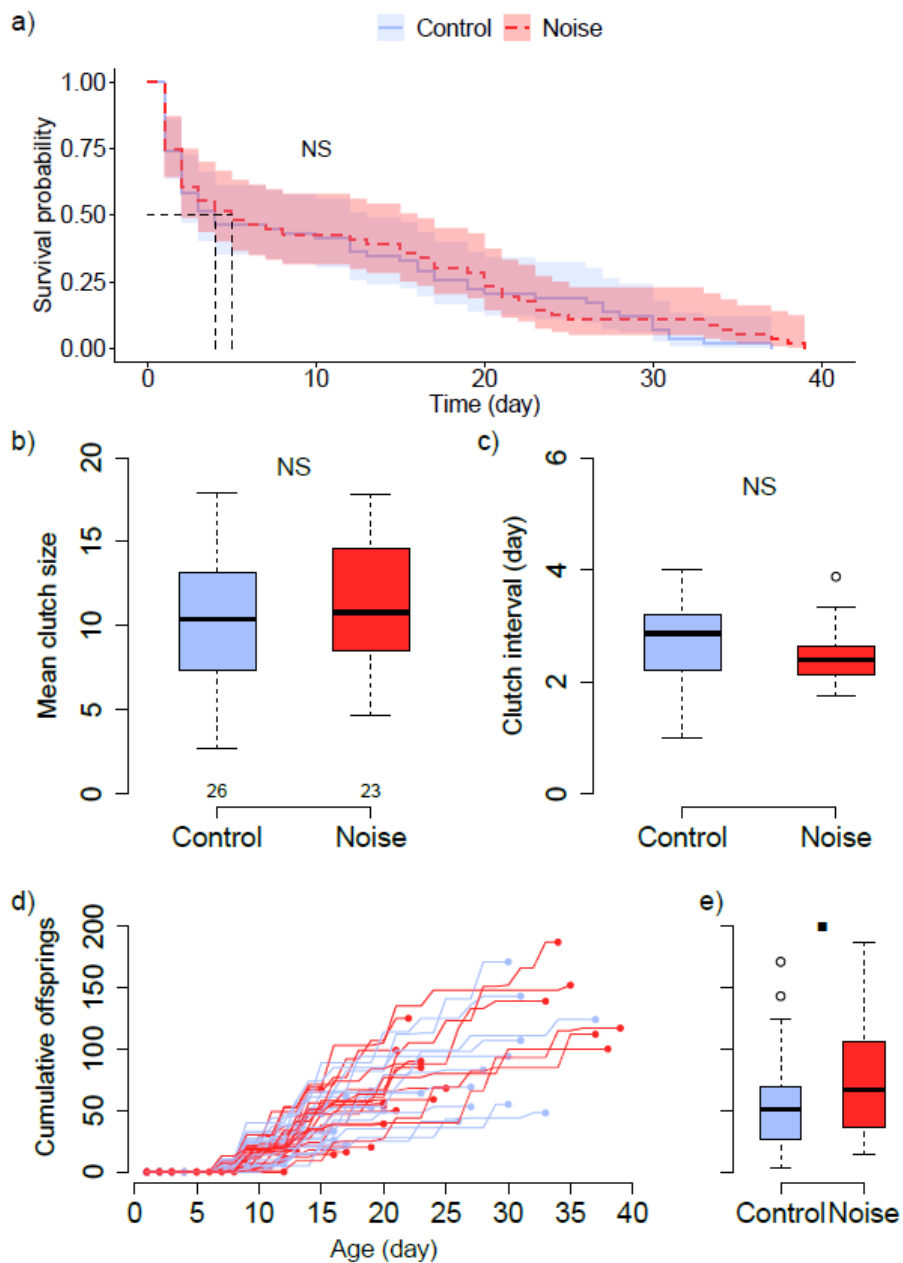


Figure 3. Effects of noise treatments on *Daphnia magna* survival and fecundity. a) Survival of *D. magna*; b) mean clutch size; c) clutch frequency; d) Cumulative offspring production along life; and e) total number of offspring during lifetime. Numbers in b) are the numbers of *D. magna* for the two treatments for b, c and e. a) Representation according to the Kaplan-Meier method; b-e) central bars represent the median, boxes the interquartile range, and dots the outliers (> 1.5 times the interquartile range). Statistical analysis: dot $P < 0.1$, * $P < 0.05$; ** $P < 0.01$; NS $P > 0.1$. See Table A1 for statistical values.

178 noise x age: p-value = 0.35, pairwise: p-values > 0.38; Fig. A1), but changed with age (p-value
 179 = 0.003) with larger clutches at intermediate ages. However, taking into account the whole
 180 lifespan, there was an effect on the total number of clutches (p-value = 0.003) with 5 clutches
 181 for the control and 6 clutches for the noise treatment, and a tendency for higher total offspring

182 production under boat noise exposure (p-value = 0.099, Fig. 3d,e), with on average 60 to 70
183 newborns.

184 The populational analysis done with the Lotka-Euler equation confirmed the tendency on
185 total offspring production with a reproductive output (R_0) higher for the noise treatment with
186 63 offspring compared to the 54 offspring in control. Generation time (G_T) was longer in the
187 noise treatment, with 16.6 days, compared to the 15.2 days in the control. The combination of
188 both led to an intrinsic rate of increase of 0.25 day^{-1} in the noise treatment compared to 0.26
189 day^{-1} in the control.

190 3. Discussion

191 This study investigated the effect of exposure to chronic boat noise on the fitness of the water
192 flea *Daphnia magna*. Contrary to what expected, no effect on the survival and fecundity
193 parameters was observed, which differed from previous results obtained with exposure to
194 another type of chronic noise. Such difference in the results might result from variations in the
195 temporal and spectral features of the noise. Moreover, as one of the first experiments on chronic
196 noise, it raises questions on the interactions with other pollutants, and on the effects on complex
197 communities.

198 Chronic boat noise had no effect on *Daphnia magna*'s fecundity and survival. These results
199 are opposite to those on acute and intense exposition of copepods to airgun. McCauley et al.
200 (2017) observed high mortality for numerous marine zooplankton species including copepods
201 following the passage of a boat equipped with an airgun. Fields et al. (2019) showed that airgun
202 exposure leads to increased mortality in *Calanus finmarchicus* within an hour. More, results are
203 opposite to those of Prosnier, Rojas, et al. (2022), where an exposition to a continuous
204 broadband noise leads to a counter-intuitive increase in *D. magna*'s fitness, with higher survival
205 and greater clutch size. Although noise had no statistical effect on the survival and fecundity

206 parameters, there was a tendency for a higher total offspring production with noise, which
207 would be consistent with the results of Prosnier, Rojas, et al. (2022). However, at a population
208 scale, the Euler-Lotka equation suggests a tendency for a lower growth when exposed to boat
209 noise due to a shorter generational time. Such differences in the magnitude of effects suggest
210 that the effect of chronic noise pollution on zooplankton species could depend on the temporal
211 and spectral structure of noise. Indeed, in Prosnier, Rojas, et al. (2022), the broadband noise
212 broadcasted was continuous, at high level (130 dB re 1 μ Pa) for all frequencies (from 0.1 to 20
213 kHz), whereas, in this study, random temporal pattern sounds (a total of 2h of noise per day)
214 with different spectra (some boat noises with low intensity between 200 and 800 Hz) were used
215 at various levels (from 108 to 136 dB re 1 μ Pa). It is already known that, in hearing vertebrates
216 (i.e., with dedicated organs to detect as inner ear sound pressure variation), animals respond
217 differently to chronic noise pollution depending on temporal variations (continuous, regular,
218 random), spectral variations (i.e., variation in the frequencies), and if noise is predictable or not
219 (Francis & Barber, 2013). Nichols et al. (2015) showed that fish were more stressed (higher
220 cortisol concentration) with a higher noise level (from 126 to 141 dB re 1 μ Pa), and under
221 intermittent random noise (i.e., unpredictable) compared to continuous noise. However, the
222 review of de Jong et al. (2020) on noise effects on fecundity revealed that continuous noise with
223 spectral variations, such as boat noise, was more prone to impact physiological markers
224 (cortisol level, ventilation rates and metabolic rate) and behaviour (startle and freeze responses,
225 horizontal and vertical avoidances). Another study on zebrafish larvae showed a higher negative
226 effect of a continuous white noise on survival and a higher cortisol concentration (Lara &
227 Vasconcelos, 2021). Thus, it seems that for hearing vertebrates, depending on the
228 developmental stage and the considered characteristic (fitness, behavior, or physiology), both
229 temporal and spectral characteristics need to be considered. For zooplankton, little is known
230 about the importance of noise characteristics. Here, the comparison with Lara & Vasconcelos

231 (2021) and Prosnier, Rojas, et al. (2022) suggests that negative effects are higher with
232 continuous noise, contrary what is reported with fishes.

233 Despite there was no effect on fecundity, it would be necessary to focus on the offspring
234 coming from mothers exposed to noise. Here, there was no qualitative effect reported during
235 the current experiments, i.e., all the water fleas produced seemed viable and mobile. More, there
236 was no increase of mortality of newborns due to noise, and no effect was reported on size of *D.*
237 *magna* exposed to chronic noise (Prosnier, Rojas, et al., 2022). This would be consistent with
238 the study of Day et al. (2016) where exposure to air gun did not affect the embryonic
239 development of the spiny lobster *Jasus edwardsii* (Decapodae). However, airgun exposition
240 reduces growth and development stage of *Acartia tonsa* nauplii (Vereide et al., 2023). This
241 aspect seems important as it is known that stress on mother and early stages can affect daphnia's
242 development (Mittmann et al., 2014; Mushegian et al., 2016) and that effects can differ across
243 generations (Campos et al., 2016). Consequently, impact studies on noise should focus on
244 embryonic development and perform multigenerational experiments to determine the long-term
245 effects of chronic exposure resulting from embryonic misdevelopment (Mushegian et al.,
246 2016), maternal effects (Radersma et al., 2018), and acclimatation or adaptation (Ringot et al.,
247 2018; Abdullahi et al., 2022).

248 An interesting perspective is to consider the effect of noise as part of cocktails of pollutants.
249 It is now a common question in ecotoxicology to ask whether stressors (e.g., chemical pollution,
250 temperature, food quality) act synergistically (Altshuler et al., 2011). For instance, Starke et al.
251 (2021) showed that food quality impacts more *D. pulicaria* at some higher temperature due to
252 the increased metabolism. Prosnier et al. (2015) modelled the antagonistic effect of copper and
253 nutrient enrichment on the *Daphnia* - algae interaction. Regarding noise, McMahon et al. (2017)
254 studied the interactive effects of light and noise pollutions on a frog-parasite interaction. They

255 showed that light reduced frog-biting midge (*Corethrella* spp.) abundance at low noise level,
256 whereas there was no midge at high noise level. It could be also useful to investigate whether
257 all the unwanted noises produced by many experimental setups (to control light, temperature,
258 oxygenation, and food) interact with the stressors studied and influence the results. For instance,
259 in the present study there was a very high mortality in *D. magna* juveniles compared to similar
260 studies (Parisot et al., 2015; Prosnier, Loeuille, et al., 2022) that suggests suboptimal conditions
261 (i.e., other stressor than noise) that might have affected the outcomes through the masking of
262 effects for example. However, on the other side, suboptimal conditions could make individuals
263 more prone to be affected by an additional stress like noise. Note that, with the same suboptimal
264 conditions, Prosnier, Rojas, et al. (2022) obtained a significant difference between the control
265 and noise treatments. The recent *Larvosonic* system, developed by Olivier et al. (2023), could
266 be useful to study the impact of noise on zooplankton with a better control of the environmental
267 conditions.

268 This study is a first step in our understanding of the importance of noise patterns for
269 invertebrates (i.e., predictable versus unpredictable noise) in comparison with vertebrates. To
270 go further, we need more information about noise perception (i.e., mechanoreception and
271 involved gene) and sensory integration, that could explain the mentioned differences between
272 vertebrates and invertebrates and seems largely unexplored (Gassie et al., 1993; Popper et al.,
273 2001). Understanding the various reaction of vertebrates and invertebrates in terms of behavior,
274 but also in terms of fitness is mandatory to study how noise could affect complex communities
275 (Francis et al., 2009; Slabbekoorn & Halfwerk, 2009; Slabbekoorn, 2019). For instance, in a
276 freshwater community, unpredictable noise should affect more fishes, at top trophic levels, than
277 invertebrates. But whether there are various effects within zooplankton community bottom-up
278 effects could also be expected. Zooplankton is highly diverse and predatory species might react
279 differently than their zooplanktonic prey. Moreover, in a community, pollutants can alter fitness

280 directly (as in this study) but also indirectly through modification of vulnerability to natural
281 enemies for instance (Read et al., 2014). For instance, noise do not affect frog abundance but
282 reduce their parasite's one (McMahon et al., 2017). The need for more research on invertebrates
283 and fitness impacts, particularly in arthropods, is also true for terrestrial communities (Morley
284 et al., 2014). Thus, a more general overview on the response of invertebrates to anthropogenic
285 noises should be beneficial to mitigate the impacts (Francis & Barber, 2013).

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296 **Conflict of interest disclosure**

297 The authors declare they have no conflict of interest relating to the content of this article.

298 **Data, script and code availability**

299 Data, script and code are available on Zenodo. DOI: 10.5281/zenodo.7775919 (Prosnier et al., 2023)

300 **Supplementary information**

301 Supplementary information is available after the references:

302 - Appendix: Tables of statistics and supplementary figure

303

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451 **Appendix: Tables of statistics and supplementary figure**

Table A1. Statistical results of chronic boat noises effects on fecundity and mortality of *Daphnia magna* (Fig. 3)

	Mortality		Reproduction			Fitness	
	Survival	Adult duration	Age at maturity	Clutch interval	Mean clutch size	Number of clutches	Number of offspring
df	1	1	1	1	1	1	1
χ^2/W	0.4	1.6	0.2	1.4029	-0.54276	3.8197	1.8263
P-value	0.51	0.21	0.65	0.236	0.737	0.031	0.099
R2	0.0041	0.03	0.0046	0.03	0.007	0.096	0.327

452

453

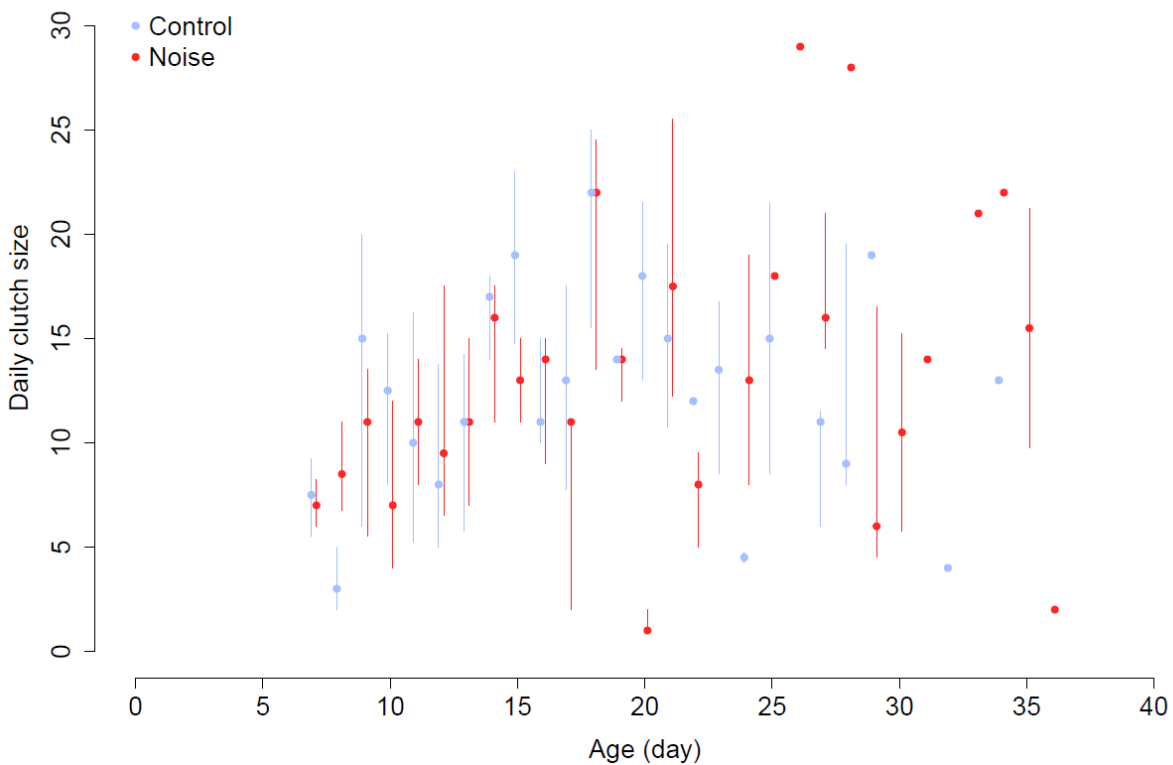


Figure A1. Effects of noise treatments on *Daphnia magna* daily clutch size. Dots represent the median of the daily clutch size and lines are interquartile ranges. See Fig. 3a,d as complement for the number of individuals at each age. Note that there could be only one clutch for an age (i.e., no interquartile lines) or clutches only for one treatment (i.e., only one point for an age).

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