frontiers

Supplementary Material

1 Appendix A: Responses of predator populations to an increase in rainfall when habitat driven hunting success decreases with rainfall

1.1 Context

The results presented in the main manuscript only accounted for a positive relationship between predator hunting success and rainfall which is expected in semi-arid ecosystems such as savanna. Hereafter, we present the methods, results and sensitivity analyses for systems characterized by the alternate relationship with hunting success decreasing as rainfall increases.

1.2 Materials and methods

The predator-prey model is the same as the one presented in the main manuscript. In this alternate situation, we again integrated the influence of habitat characteristics that could affect prey vulnerability through the manipulation of the handling time *h*. However, here we assumed that handling time *h* would increase with rainfall and that higher rainfall levels would correspond to higher *h* values and consequently longer times to subdue one prey, i.e. decreased hunting efficiency and success than at lower rainfall levels (Fig. S1). Therefore, *h* varies with rainfall according to the following equation:

$$\mathrm{H}(R) = h_{min} + \frac{h_{max} - h_{min}}{1 + e^{-B(R-V)}} \quad (1)$$

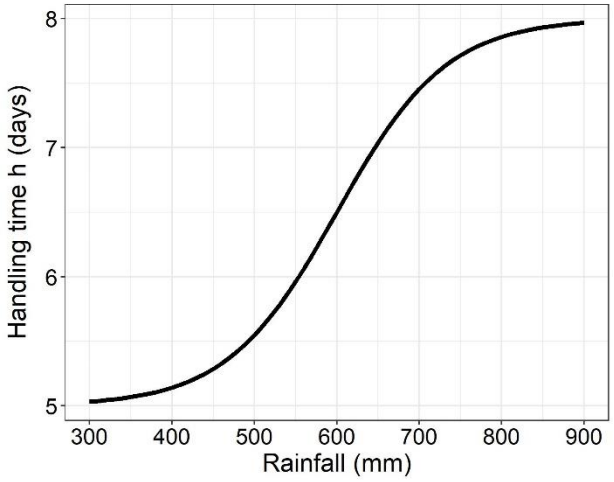


Figure S1: Functional relationship between rainfall and predator handling time *h* as defined by (1). The hunting success varies inversely with the handling time. For parameters see Table 1 of the main manuscript.

1.3 Results

1.3.1 Immediate response of predator populations to specific rainfall conditions

When climatic conditions influenced prey abundance only (scenario 1), the population growth rate of predators was not influenced by the specific climatic condition of the year (Fig. S2A). In contrast, in the three other scenarios, the population growth rate of predators in one year was influenced by the specific climatic condition of the year. Predators from the three scenarios, benefited from below-

average rainfall (600mm) and their populations increased, but were negatively impacted by increasing rainfall (Fig. S2A). Finally, unlike the results presented in the main manuscript, the combination of vulnerability effects in scenario 4 made this scenario the one with the most extreme responses, and predator growth rates were negative at above-average rainfall and positive at below-average rainfall (Fig. S2A).

1.3.2 Long-term response of predator populations to changes in mean annual rainfall

Over the long term, our results show here again an effect of mean annual rainfall on the size of predator populations for all scenarios. Scenario 1 and 2 show similar patterns as those presented in the main results, as the size of predator populations increased near-linearly with rainfall for both scenarios and scenario 2 being characterized by lower predator population size than scenario 1. The size of predator populations in scenario 3 and 4 also varies non linearly, displaying a unimodal response to increasing rainfall. In scenario 3, the size of predator population first increased with increasing mean annual rainfall, before decreasing (Fig**.** S2B). The size of predator populations in scenario 3 were greater than those from scenario 2 up until mean annual rainfall reached values around 600mm, but were smaller for values above (Fig. S2B). The size of predator populations from scenario 4 varied virtually identically as in scenario 3 with rainfall but with lower values of predator population sizes (Fig. S2B).

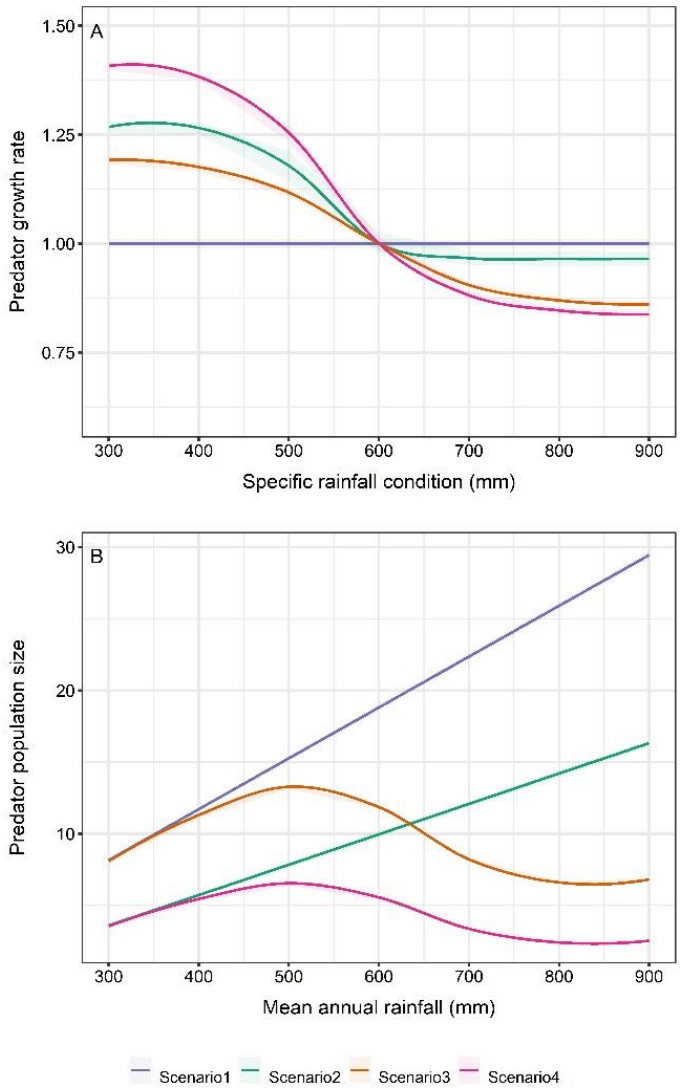
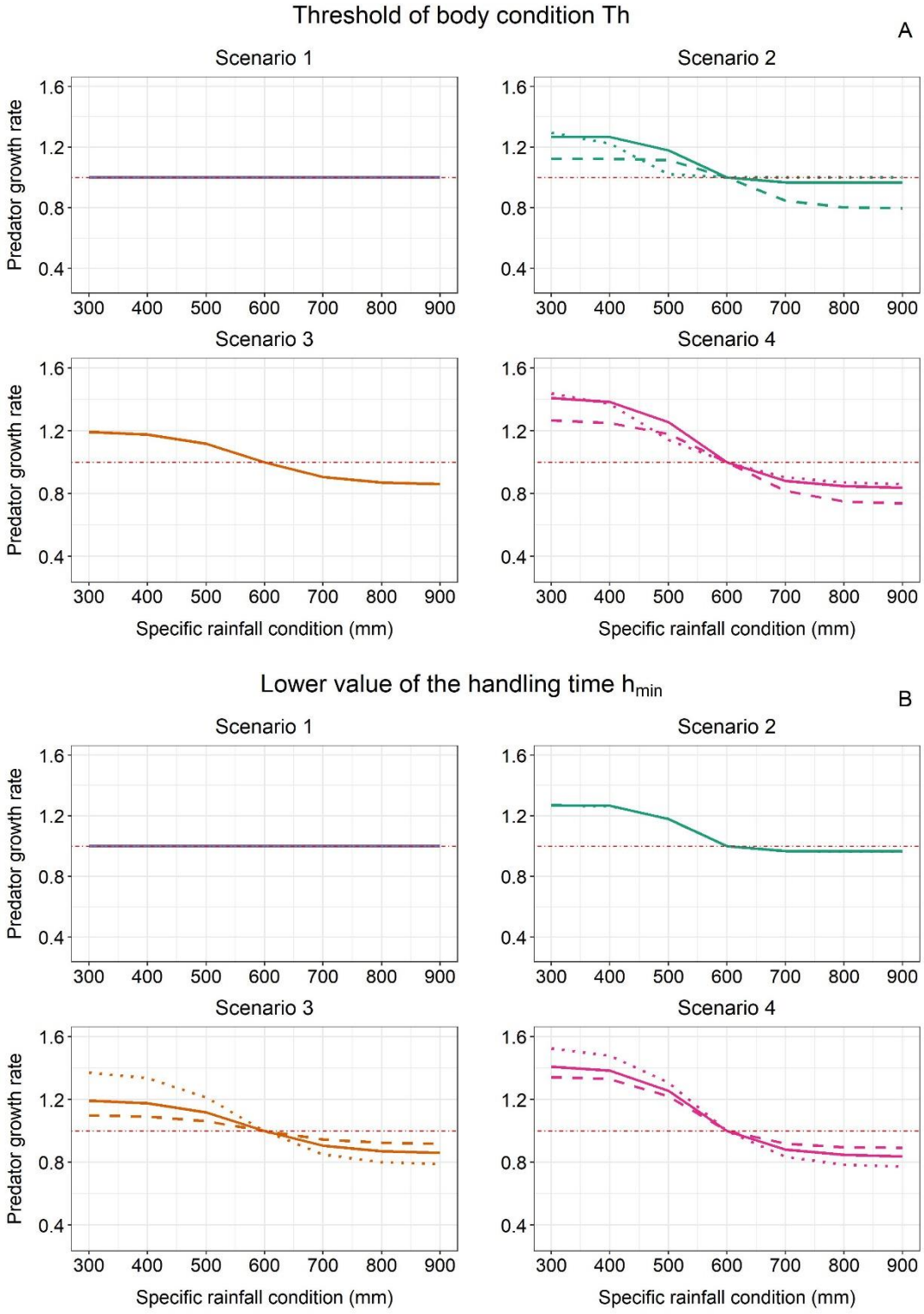


Figure S2: (A) Immediate response of predator populations to a specific rainfall condition. Relationship between the growth rate of predator populations and a specific annual rainfall in a system characterized by a long-term mean annual rainfall of 600 mm. (B) Long-term response of predator populations to changes in mean annual rainfall. Relationship between the size of predator populations and long-term mean annual rainfall. Light-coloured envelops include minimum and maximum values of predator growth rates (A) and mean population size (B).

1.4 Sensitivity analyses

Sensitivity analyses of the immediate response of predator to 20% change in parameters when the habitat-driven hunting success decreases with rainfall.



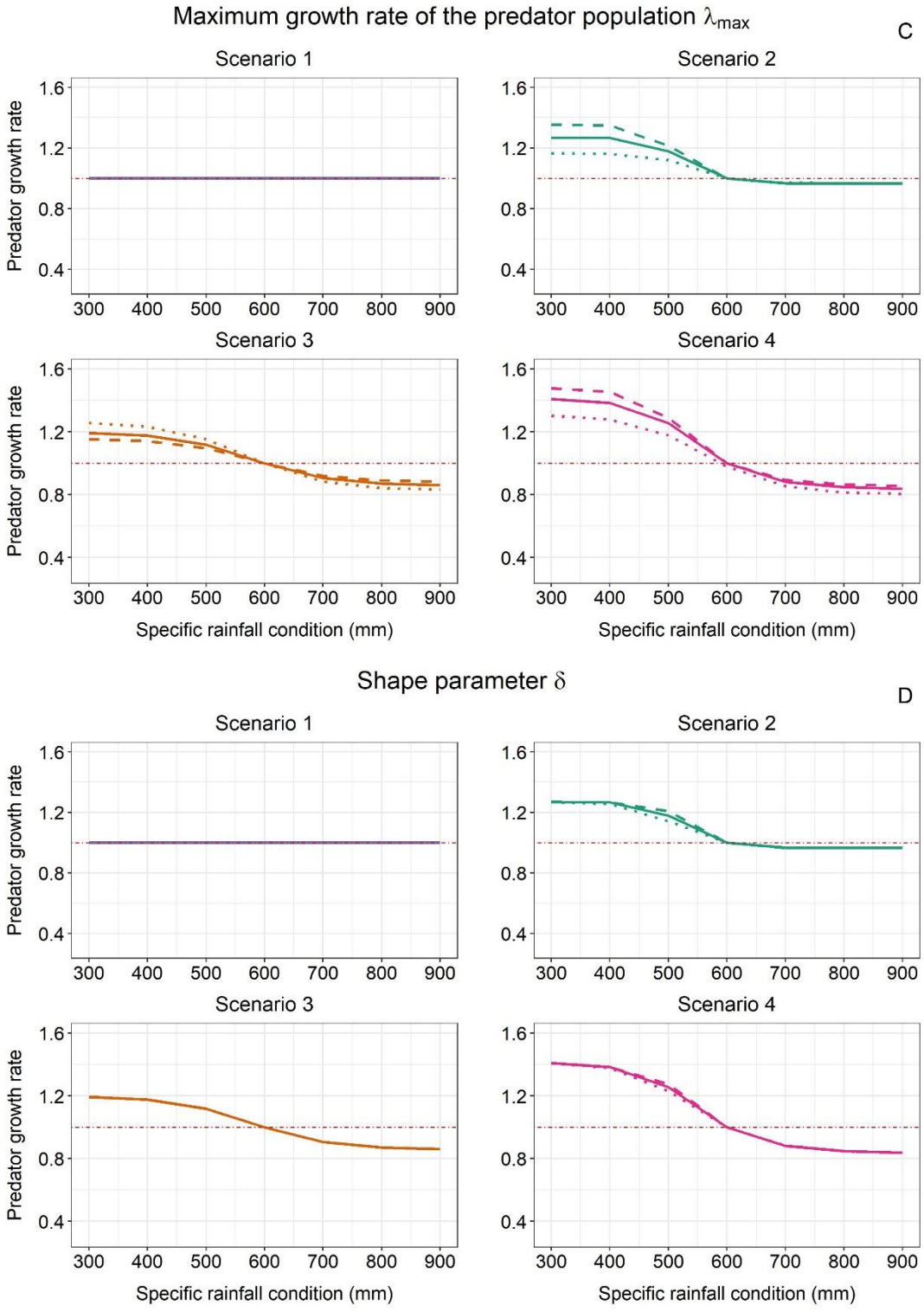
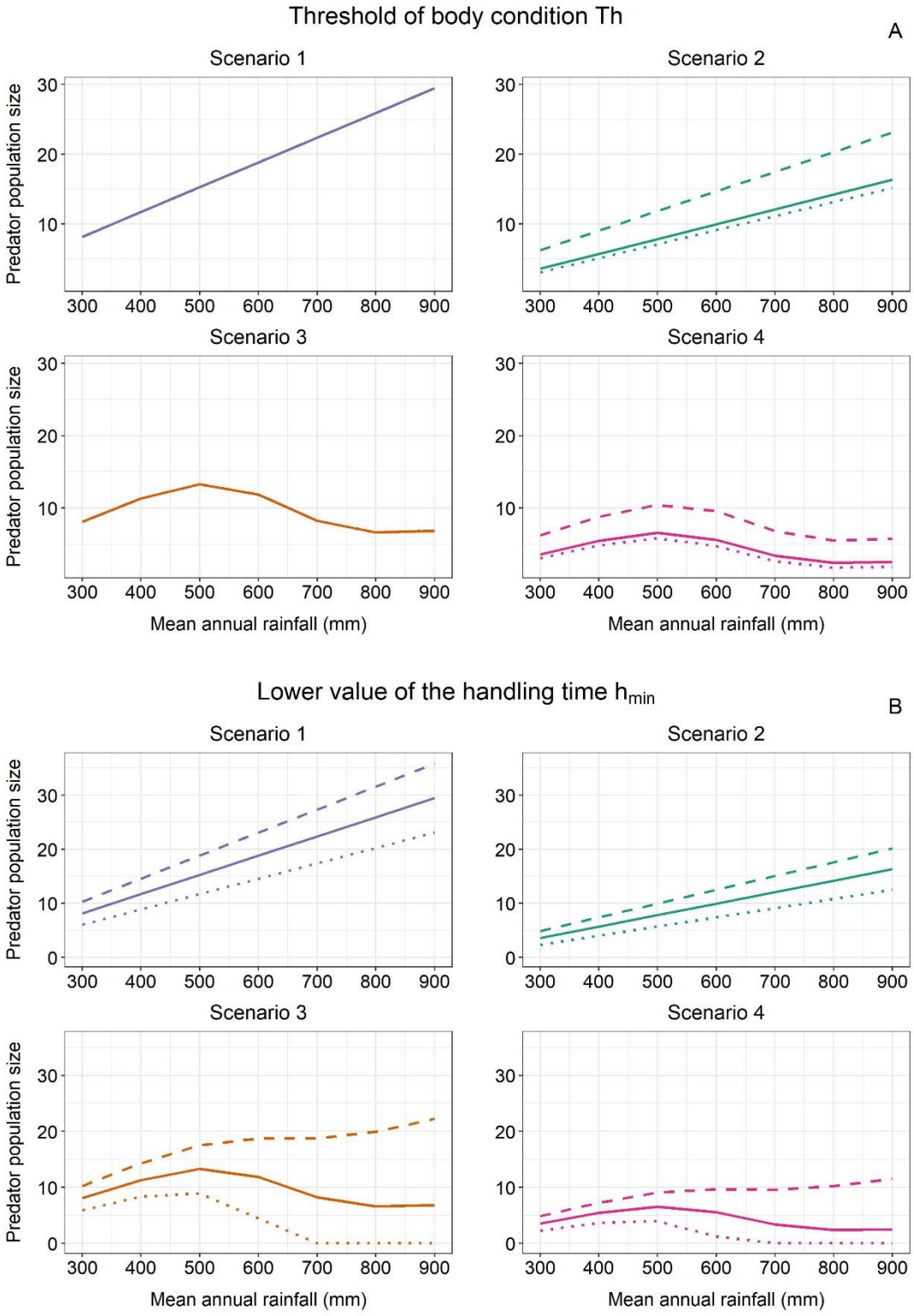


Figure S3: Influence of a specific rainfall condition on the growth rate of predators from the four scenarios for three values (default: solid line, + 20%: dashed line, -20%: dotted line) of tested parameters: (A) *Th*, (B) h_{min}, (C) λ_{max}, (D) δ, when the habitat-driven hunting success decreases with rainfall. All other parameters are set to default values. Red dotted lines correspond to a predator growth rate equal to 1.

Sensitivity analyses of the long-term response of predators to 20% change in parameters when the habitat-driven hunting success decreases with rainfall.



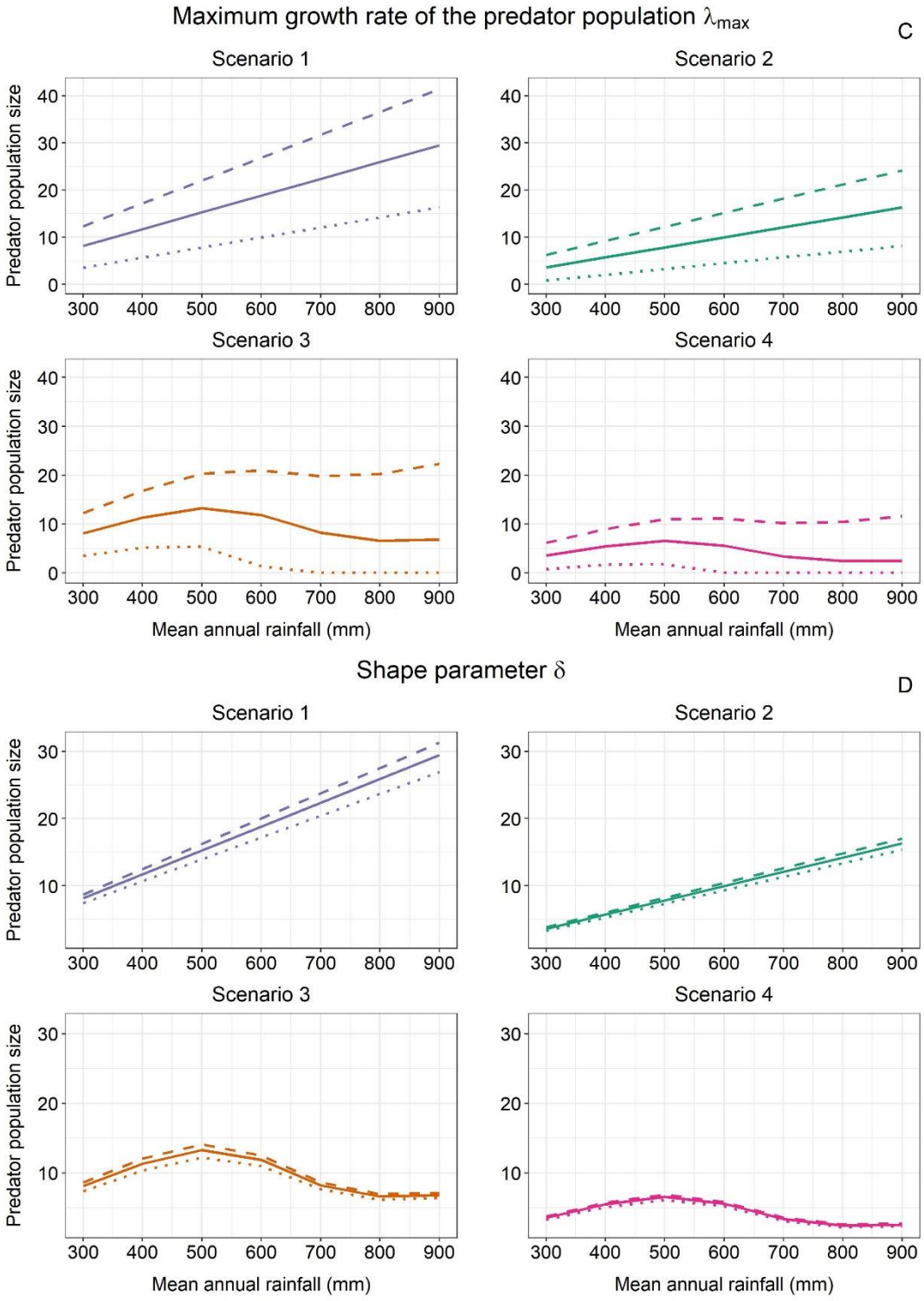


Figure S4: Influence of long-term mean annual rainfall on the size of predator populations from the four scenarios for three values (default: solid line, + 20%: dashed line, -20%: dotted line) of tested parameters: (A) *Th*, (B) h_{min}, (C) λ_{max}, (D) δ, when the habitat-driven hunting success decreases with rainfall. All other parameters are set to default values.

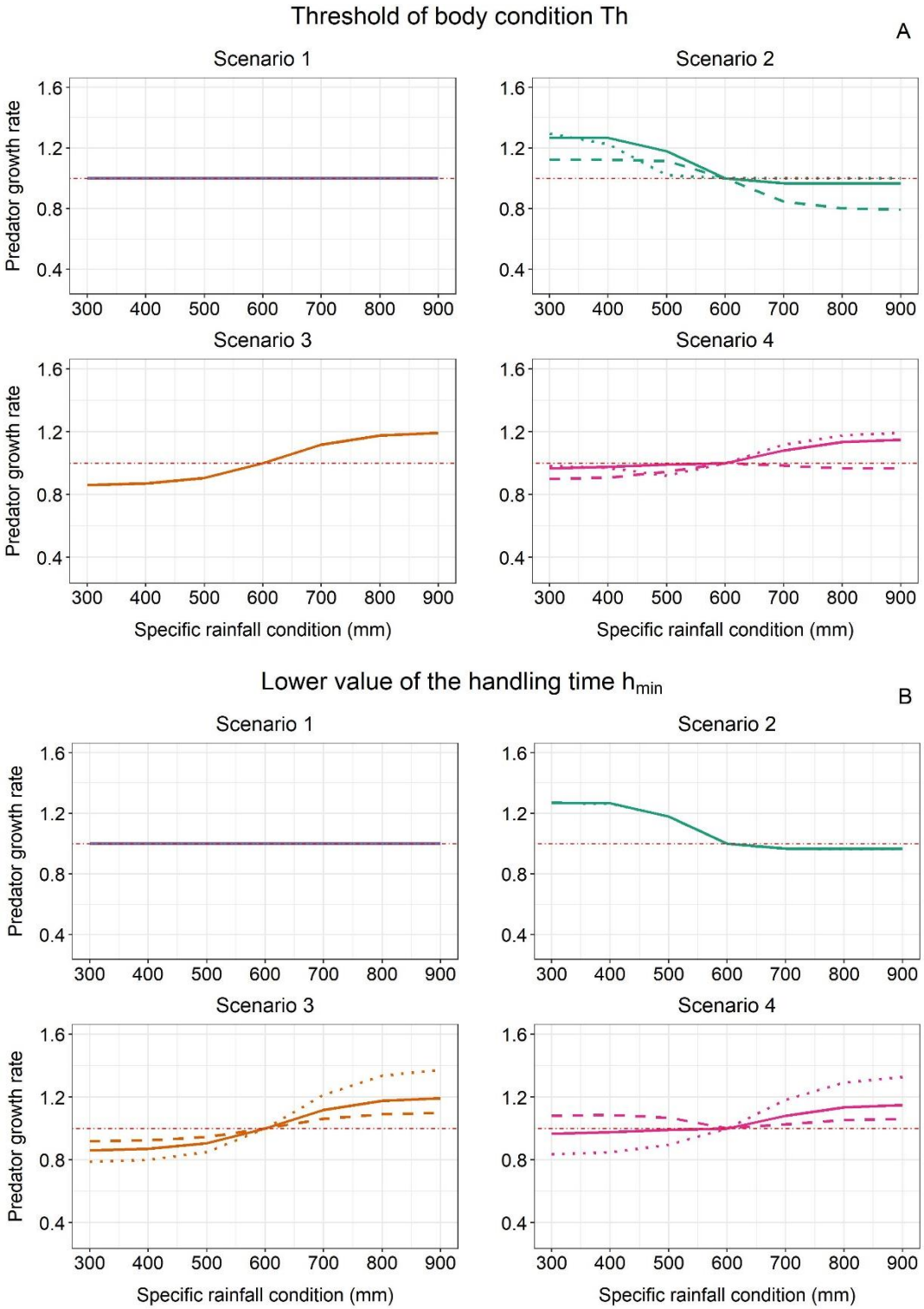
2 Appendix B: Sensitivity analyses

2.1 Results of sensitivity analyses

Sensitivity analyses showed that the results observed were robust to changes in the 4 study parameters as decreasing or increasing parameter values by 20% mostly triggered quantitative rather than qualitative changes in the patterns compared to those displayed for defaults values (Figures S5 and S6). However, we can note that when we increase *Th* by 20% for scenario 4 (Figure S5A), the predator population growth rate remains below 1 for high values of rainfall contrary to our expectation. However, it remains greater than the growth rate observed for lower values of rainfall. Additionally, other particular cases arise when we increase λ_{max} and h_{min} by 20% for scenario 4 (Figures S5B and S5C), for small rainfall values. The explanation probably lies in the fact that λ_{max} and P_{rel}, which contains h_{min} in its denominator as shown by *eqn. 11*, are both included in *eqn. 10* but reached values too high for the effect of prey populations on predators to be still detectable in comparison to the rate of increase of predator population. This allowed the rate of increase to remain positive and predator populations to increase.

2.2 Figures

Sensitivity analyses of the immediate response of predators to 20% change in parameters.



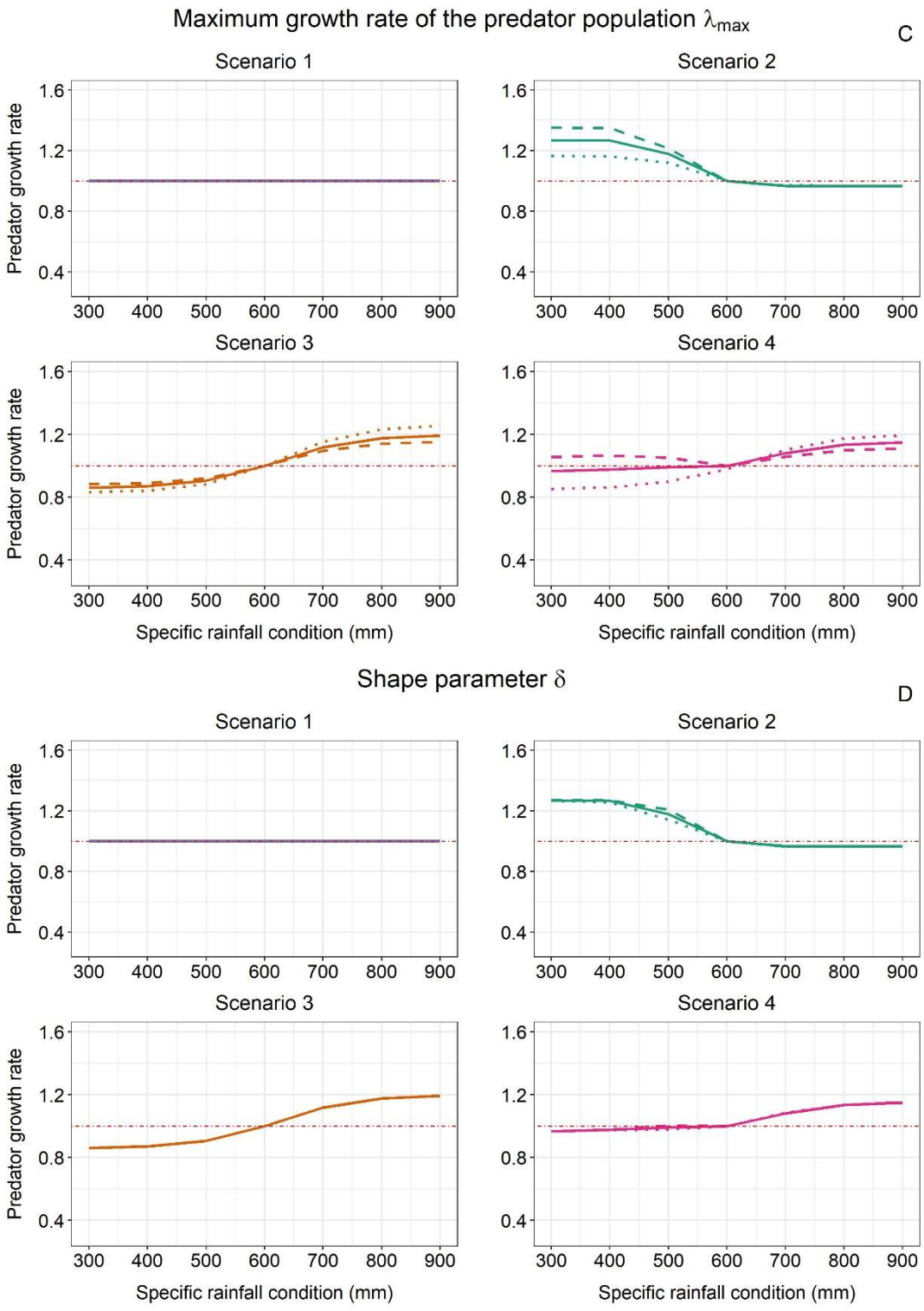
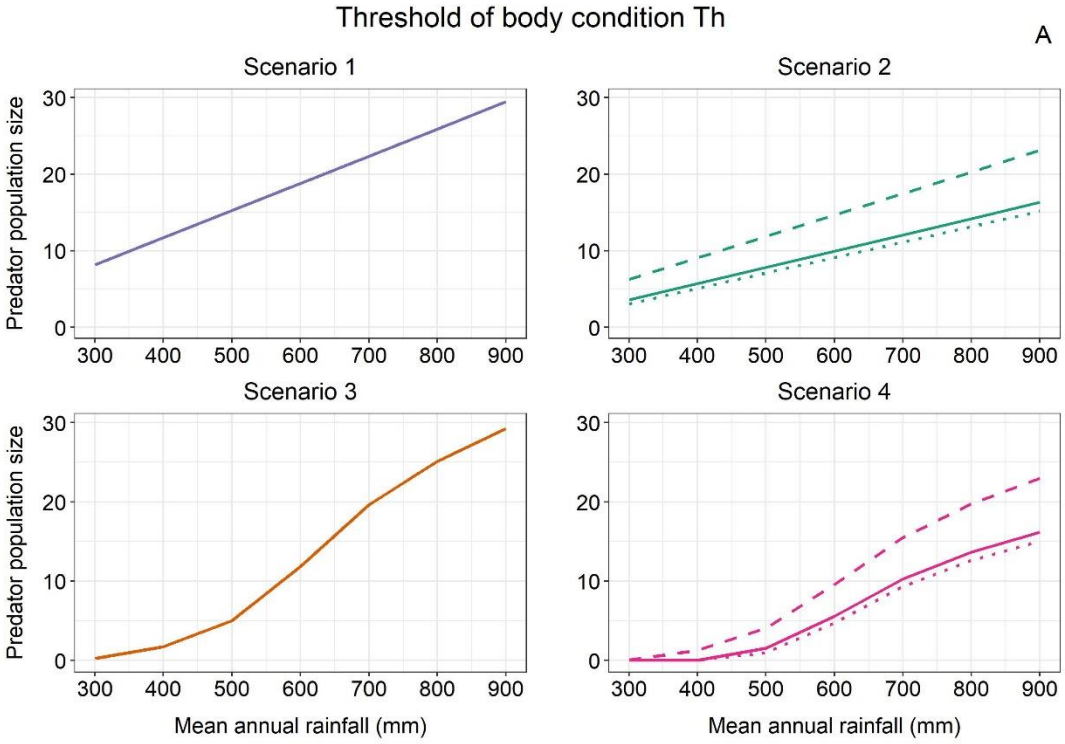
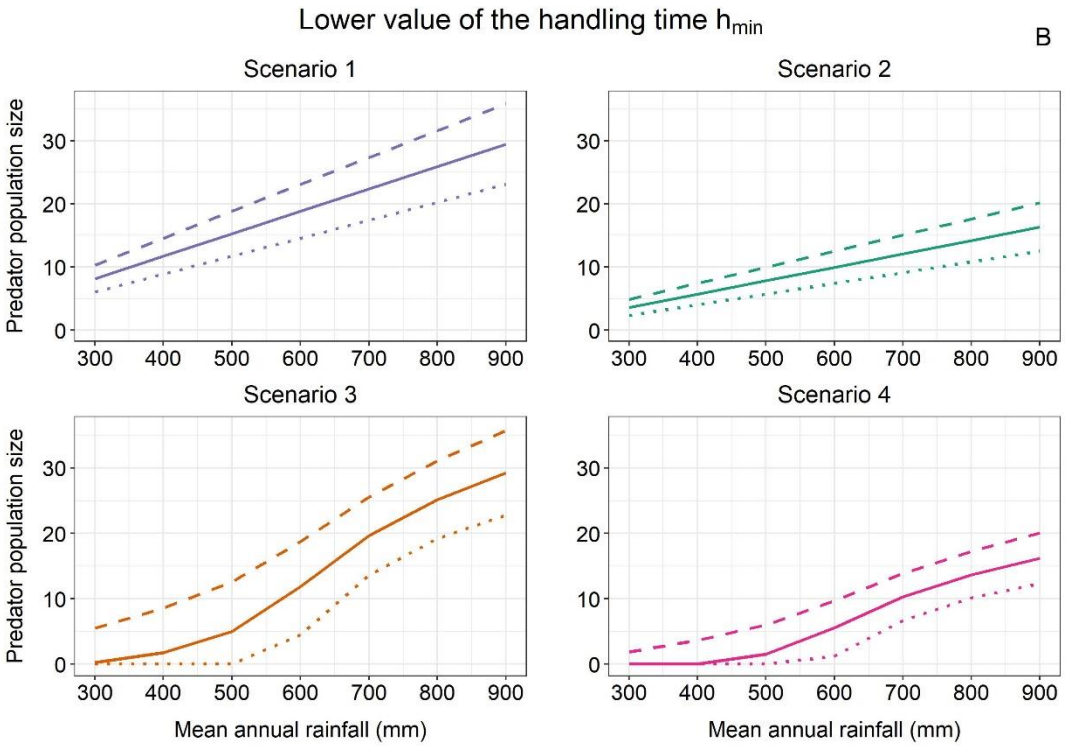


Figure S5: Influence of a specific rainfall condition on the growth rate of predators from the four scenarios for three values (default: solid line, + 20%: dashed line, -20%: dotted line) of tested parameters: (A) *Th*, (B) h_{min}, (C) λ_{max}, (D) δ. All other parameters are set to default values. Red dotted lines correspond to a predator growth rate equal to 1.

Sensitivity analyses of the long-term response of predators to 20% change in parameters.





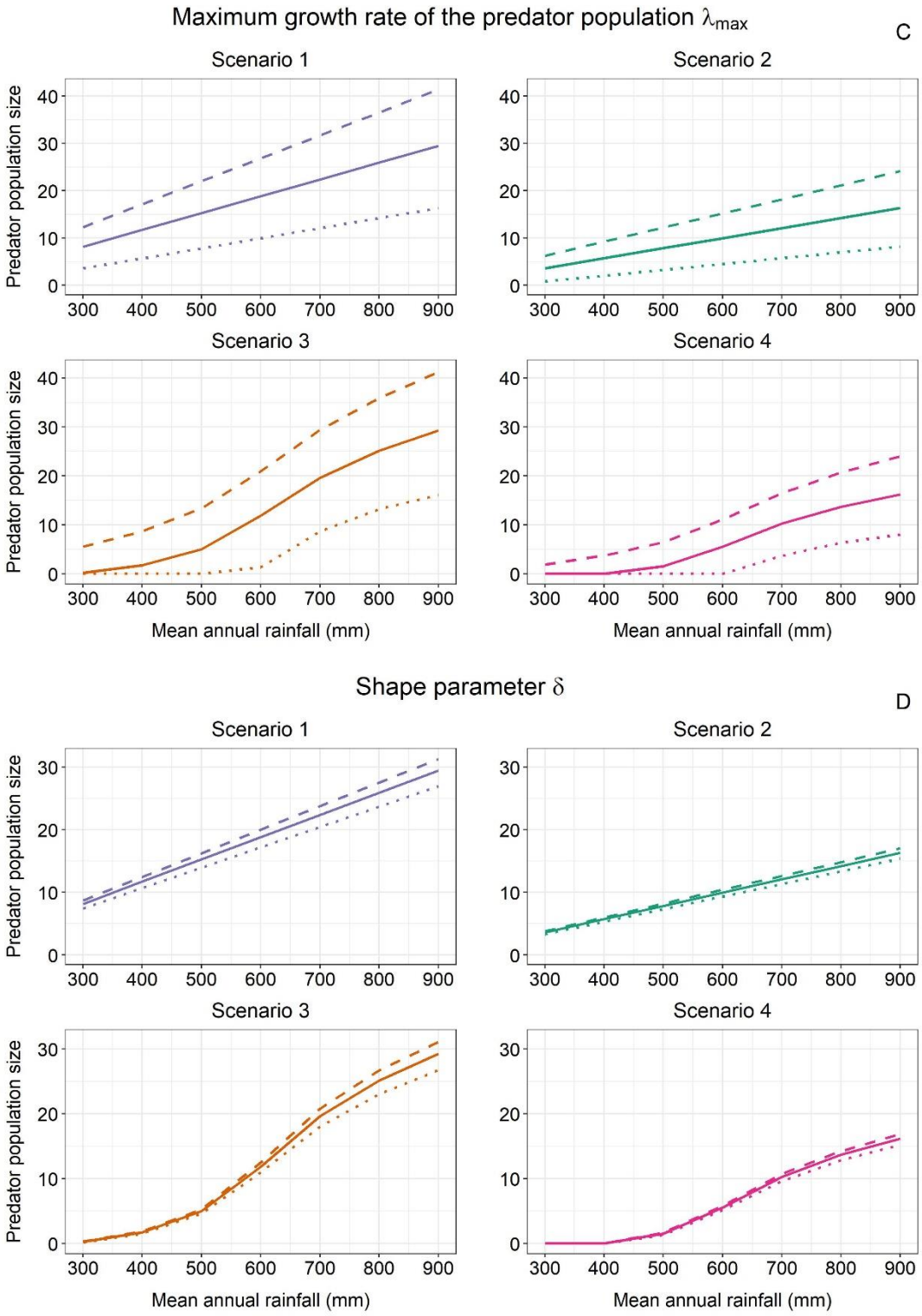


Figure S6: Influence of long-term mean annual rainfall on the size of predator populations from the four scenarios for three values (default: solid line, + 20%: dashed line, -20%: dotted line) of tested parameters: (A) *Th*, (B) h_{min}, (C) λ_{max}, (D) δ. All other parameters are set to default values.

3 Appendix C: Supplementary figures

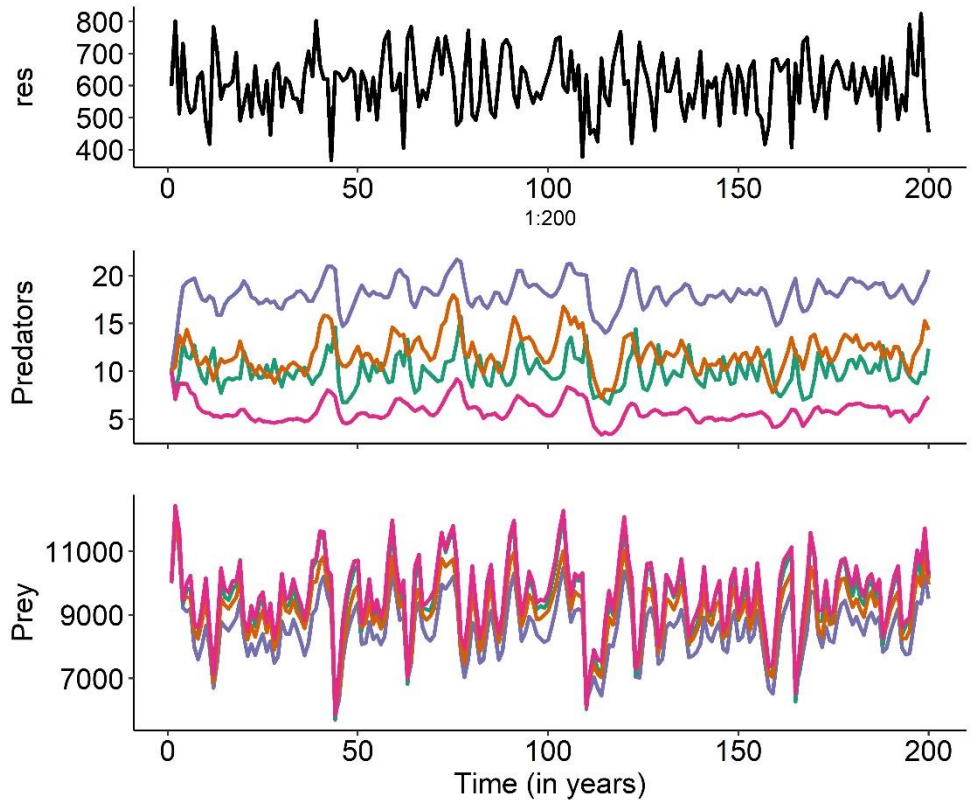


Figure S7: Model behaviour for one run. Rainfall (top), predator (middle) and prey (bottom) population sizes, for a 200-year run. Used parameter values are presented in Table1.

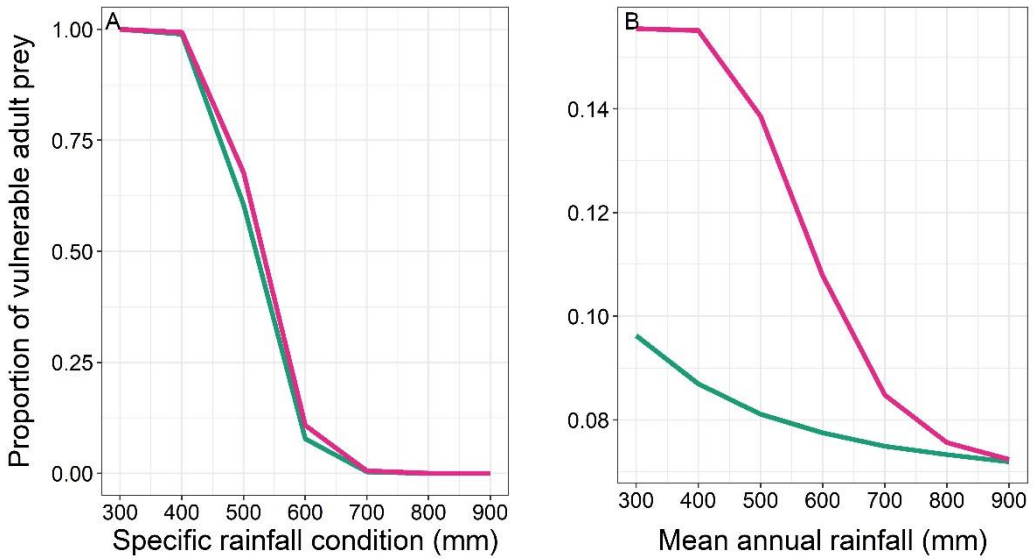


Figure S8: (A) Influence of a specific rainfall condition on the proportion of adult prey vulnerable to predators in scenarios 2 (green) and 4 (pink). (B) Influence of mean annual rainfall on the proportion of adult prey vulnerable to predators in scenarios 2 (green) and 4 (pink). By definition the proportion of adult prey for predators from scenarios 1 and 3 is set to 1.

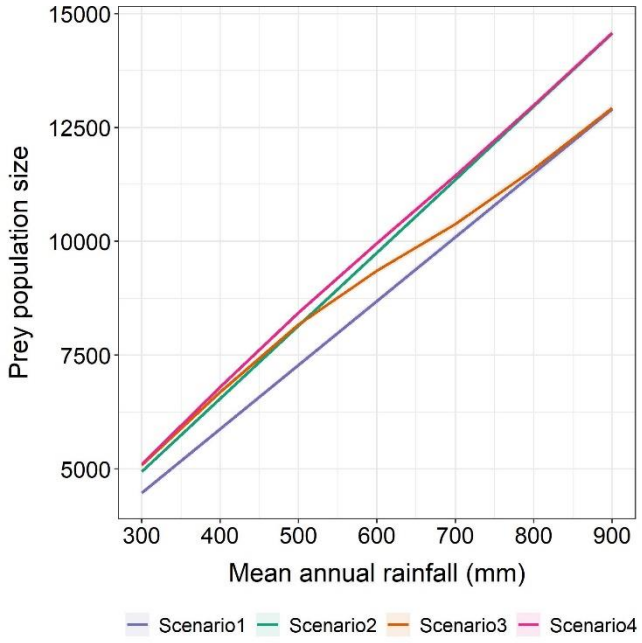


Figure S9: Influence of mean annual rainfall on the size of prey populations, for the four scenarios.