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LACK OF DATA ON THE COLONIZATION BY AMPHIBIANS
AND REPTILES OF THE ECOSYSTEMS DEVELOPING
AFTER THE RETREAT OF GLACIERS

SUMMARY

Glaciers show a pattern of retreat at the global scale. As a consequence, increasing surfaces are exposed and colonized by multiple organisms. Deglaciating areas provide a great opportunity to understand species responses to climate change. A growing number of studies is assessing how the organisms colonize recently deglaciating terrains. By performing a literature review, we showed that in the period 1990-2020 about 900 studies have analysed the dynamics of biotic communities after glacier retreat, 20% of which focused on animals. Some species of both amphibians and reptiles have adaptations for cold environments that allow them exploiting high-altitude environments, and a few studies described their presence in recently deglaciating terrains. For instance, in the Alps *Rana temporaria* is able to breed in small lakes a few decades after the retreat of glaciers, nevertheless information on the topic remains anecdotal. In order to evaluate the status of research, we performed a systematic review on the ISI Web of Science. The literature search returned very few studies (0.1% of the total) performing quantitative analyses on the recent dynamics of colonization of deglaciating terrains by amphibians or reptiles. Deglaciating terrains will soon constitute a major component of high-mountain ecosystems. Focused studies are urgently needed to understand how and at which rate amphibians and reptiles respond to these major environmental modifications.

Key words: Global warming, meta-analysis, glacier retreat, primary succession.

RIASSUNTO

Assenza di informazione sulla colonizzazione da parte di anfibi e rettili degli ecosistemi che si sviluppano dopo il ritiro dei ghiacciai. I ghiacciai stanno ritirandosi a scala globale a causa del riscaldamento climatico: ampie superfici sono quindi esposte e colonizzate dagli organismi. Lo studio delle aree recentemente deglacciate è estremamente utile per comprendere la risposta degli animali ai cambiamenti globali e sempre più studi stanno analizzando lo sviluppo delle comunità dopo il ritiro dei

ghiacciai. Diverse specie di anfibi e rettili hanno adattamenti che permettono di vivere in alta montagna, ed esistono numerose osservazioni di anfibi e rettili in aree recentemente deglacciate. Per esempio *Rana temporaria* si riproduce in alcuni laghetti proglaciali pochi decenni dopo il ritiro dei ghiacciai. Abbiamo effettuato una rassegna bibliografica tramite ISI Web of Science per valutare le conoscenze su questo tema. Nel periodo 1990-2020 circa 900 studi hanno analizzato la colonizzazione delle aree lasciate libere dai ghiacciai (aree proglaciali), il 20% dei quali hanno considerato animali. Pochissimi studi (0.1% del totale) hanno però effettuato analisi quantitative su anfibi e rettili. Le aree deglacciate saranno presto una componente rilevante degli ambienti di alta montagna. Sottolineiamo l'importanza di più studi sull'argomento, per capire meglio come anfibi e rettili risponderanno ai cambiamenti ambientali causati dal riscaldamento globale.

Parole chiave: cambiamento climatico, meta-analisi, ritiro dei ghiacciai, successione primaria.

INTRODUCTION

Glaciers show a pattern of retreat at the global scale at a rate that is accelerating in recent decades (HOCK *et al.*, 2019; ZEMP *et al.*, 2019). As a consequence, increasing surfaces are exposed and colonized by multiple organisms. Ice-free areas provide a great experimental system for understanding species responses to climate change, colonization patterns, community formation and dynamics. The last 30 years have seen crucial advances in our understanding of biotic colonization after glacier retreats, resulting from the integration of methodological innovations and ecological theories (FICETOLA *et al.*, 2021). A growing number of studies is assessing how the different organisms colonize recently deglacciated terrains (ERSCHBAMER & CACCIANIGA, 2016; DONHAUSER & FREY, 2018; CAUVY-FRAUNIÉ & DANGLES, 2019; HÅGVAR *et al.*, 2020). Some species of both amphibians and reptiles have adaptations for cold environments that allow them exploiting high-altitude environments. For instance, in the Alps there are several records of *Rana temporaria* breeding in small lakes a few decades after the retreat of glaciers, nevertheless information on the topic remains anecdotal, and a global analysis of the colonization patterns of deglacciated terrains in amphibians and reptiles is still lacking.

METHODS

In order to evaluate the status of research on this topic, we performed a systematic review on the ISI Web of Science using the following search terms: TS = {glacier* AND [colonization OR biotic OR succession OR (ecosystem dynamic*)]} without temporal constraints. We only retained studies describing patterns of biotic colonization; retained studies were complemented with the ones in the meta-analysis by CAUVY-FRAUNIÉ & DANGLES (2019).

RESULTS AND DISCUSSION

This search showed that in the period 1990-2020 about 900 studies have analysed the recent dynamics of biotic communities after glacier retreat (Fig. 1), 20% of which focused on animals. However, for amphibians and reptiles the literature searches mostly returned studies focusing on the colonization routes after the end of Quaternary glaciations. Just 0.1% of retained studies performed quantitative analyses on the recent dynamics of colonization of deglaciated terrains by amphibians and no one on reptiles, hampering any quantitative synthesis of patterns and processes in these organisms. Global change models consistently indicate that deglaciated terrains will soon constitute a growing component of high-mountain ecosystems (HOCK *et al.*, 2019). Focused studies are urgently needed to understand how and at which rate amphibians and reptiles respond to these major environmental modifications triggered by climate change, and how colonization dynamics occur.

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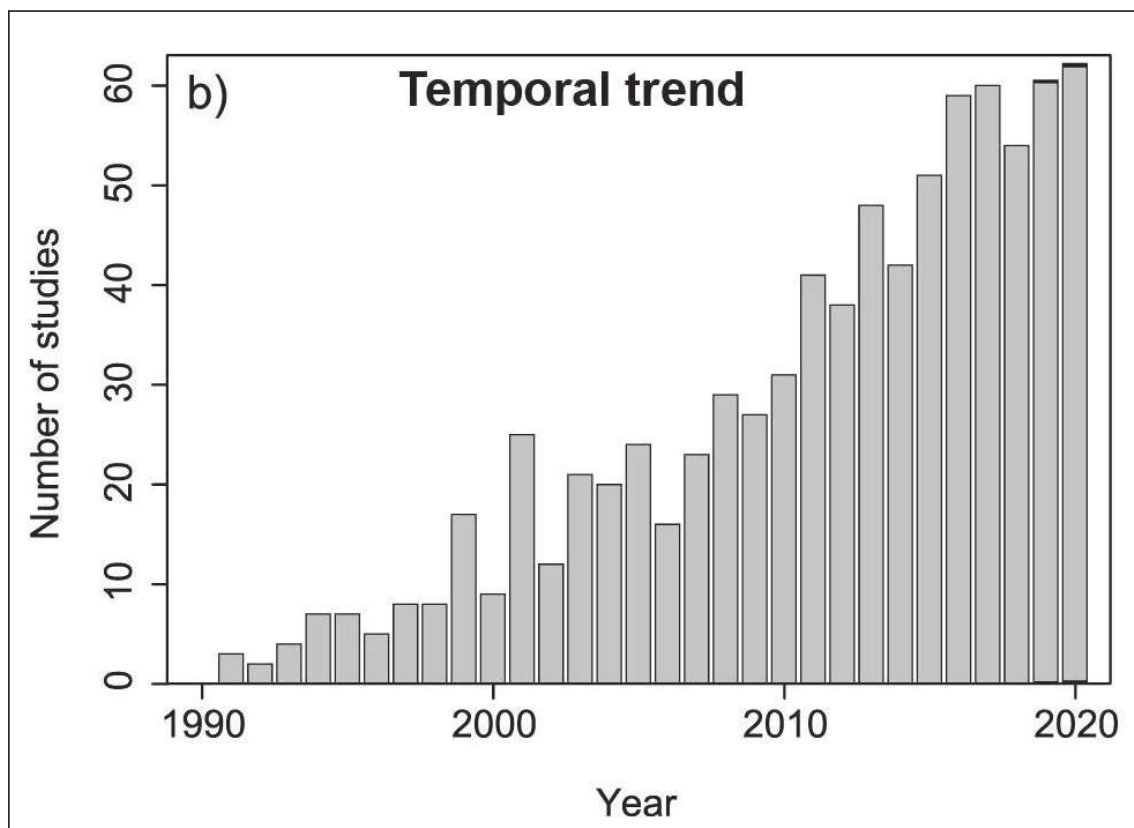


Fig. 1 — Temporal trend in research on community dynamics after glacier retreat. Studies covered a very broad range of organisms, but just 0.1% focused on amphibians, and none on reptiles.

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