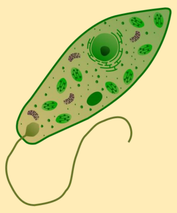
Forecasting in the face of ecological complexity:

Number and strength of species interactions determine forecast skill in ecological communities



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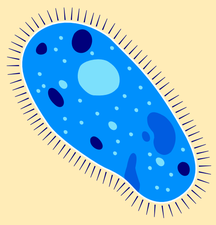
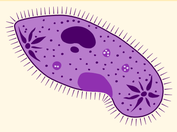


BACKGROUND



- It is challenging to forecast the ecological consequences of climate change, biodiversity loss, etc.
- The complexity of ecological systems might render ecology unpredictable[1]
- Studies both support[2] and refute[3] that complexity hinders forecast skill
- Complexity within a system varies as well: species differ in how many interactions they have and how strong these are
- Yet, little is known about how within system complexity is related to forecast skill

RESEARCH QUESTIONS

- Does the forecasting of species abundances depend:
  1. On the number of interactions a species has?
  2. On the mean strength of these interactions?

  ⟶ Forecast skill vs. complexity **within** system
- Does an increase in complexity decrease how well we can forecast species abundances?

  ⟶ Forecast skill vs. complexity **across** systems

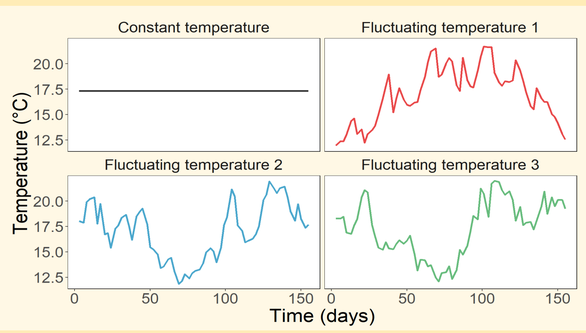
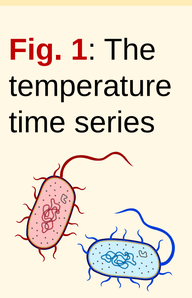


Fig. 1: The temperature time series



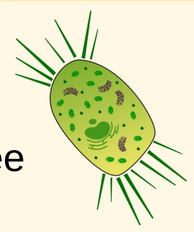
METHODS

Experiment

- Microcosms: tri-trophic microbial communities in 2L **bottles**
- Treatment: 1 constant and 3 fluctuating temperatures (Fig. 1)
  ⟶ The fluctuating temperatures complexify the system
- Replicates: 9 at constant and 3 at each fluctuating temperature
- Sampling: 3 times per week (Mo, We, Fr) for 22 weeks

Analyses

- Time series: detrended and standardized
- Forecast error of abundances determined with three methods: EDM, ARIMA & RNN
- Number of interactions: estimated with CCM EDM
- Interaction strengths: estimated with S-map EDM & MARSS



RESULTS

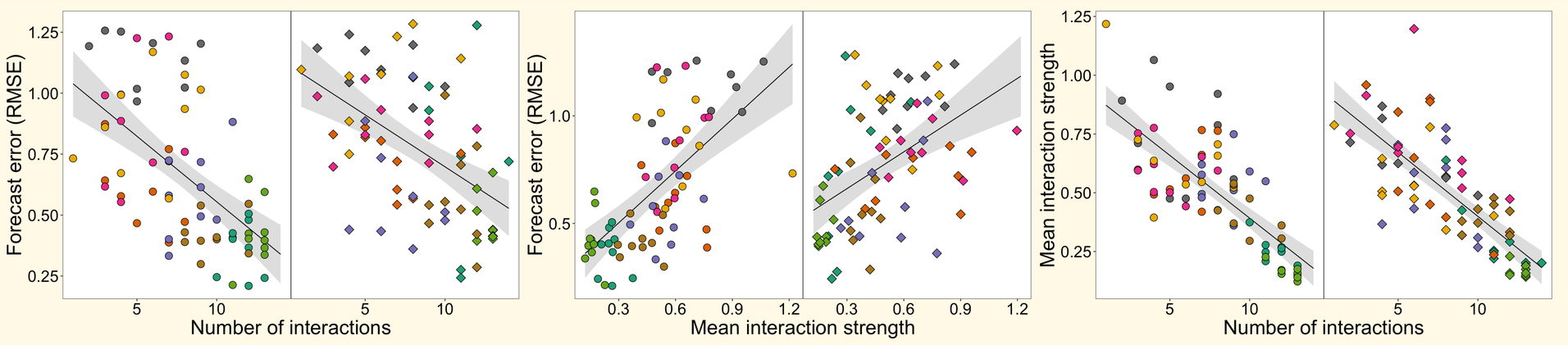


Fig. 2: The more interactions a species had, the weaker these interactions were and the better its abundance was predicted

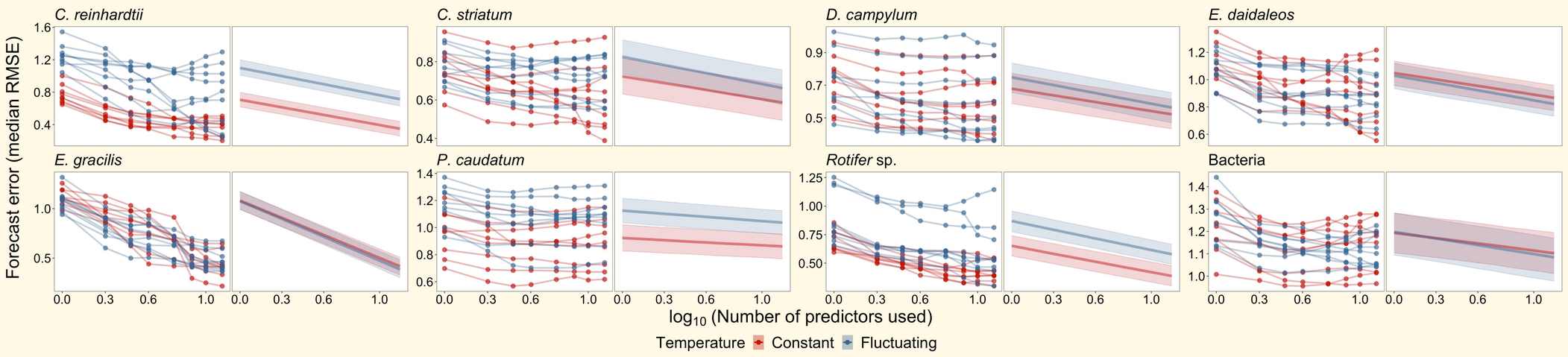
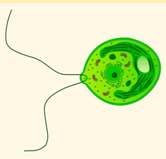
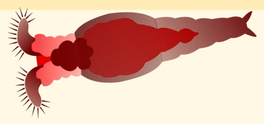


Fig. 3: The greater system complexity (i.e. the fluctuating temperatures) increased the forecast error for 3 out of 8 species

CONCLUSIONS





Within the system, complexity improved forecasting (Fig. 2)

- To forecast abundances equally well different amounts of data are required for different species

Increased system complexity decreased the forecast skill of some species (Fig. 3)

- The effect of complexity can be species-specific and of different sign within and across systems

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See the publication in Ecology Letters!

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REFERENCES

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GLOSSARY

ARIMA: Auto-Regressive Integrated Moving Average
CCM: Convergent Cross Mapping
EDM: Empirical Dynamic Modeling
MARSS: Multivariate Auto-Regressive State Space
RNN: Recurrent Neural Network
S-map: Sequential Mapping