A standard protocol to report discrete stage-structured demographic information

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SUPPLEMENTARY ONLINE MATERIALS

A survey on matrix communication

Title:
MPMs in the Literature

Section 1: Description

Thank you for taking this 2-minute survey. We really value your input. The main goal of this survey is to assess the ability of publications using MPMs to impart sufficient information about MPM construction.

All answers are anonymous, and participants can end the survey at any time.

Below, you will find two questions gauging your use of matrix population models (MPMs) in your research. Subsequently, there are statements about how MPMs and their associated information are reported in the literature. To complete the survey, please indicate to what extent you agree with the proposed statements.

The ratings represent:

1 = strongly disagree
2 = disagree
3 = neither agree nor disagree
4 = agree
5 = strongly agree

Section 2: General information

1. How many years have MPMs been involved in your research
    a. Possible answers:
        i. 1
        ii. 2
        iii. 3
        iv. 4
        v. 5
        vi. 5+
2. You are comfortable at building stage-structured population models (*i.e.*, MPMs or IPMs).
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree

Section 3: MPMs in research

1. Population ecologists who use MPMs describe the methods associated with building the MPMs form raw data adequately for reproducibility in peer-reviewed publications.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree
2. Papers using MPMs identify and clearly define the names of stage/age/size classes used in their structure.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree

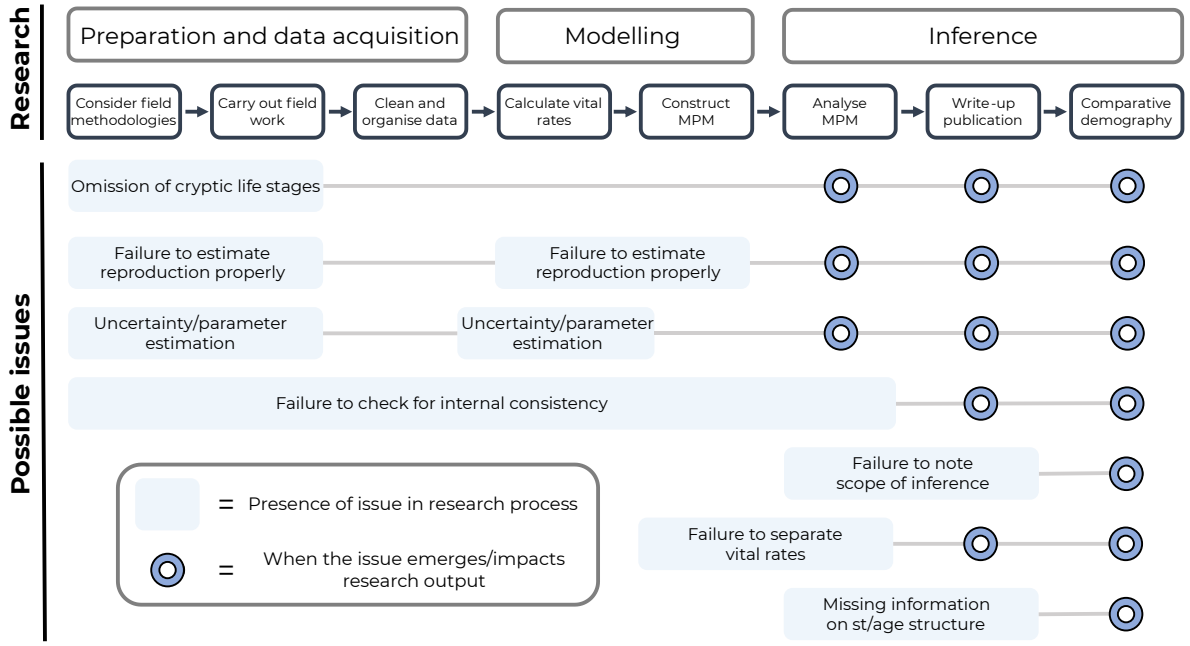
iii. Neither agree nor disagree
iv. Agree
v. Strongly agree

3. Census duration, the period of time data are recorded (*e.g.*, 6 months, 10 years), is reported with the MPMs in peer-reviewed publications.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree
4. Projection interval, the period of time between censuses (*e.g.*, 3 months, 1 year), is reported with the MPMs in peer-reviewed publications.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree
5. Authors detail the formulas used to calculate vital rates (*i.e.*, attributions from survival, sexual reproduction, clonal reproduction, retrogression towards a single matrix element) in peer-reviewed publications.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree
6. The life-cycle graph, which illustrates the discrete transitions involved in an MPM, is present in peer-reviewed publications using MPMs.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree
7. Population vectors, which define the structure of the population, are explicitly reported in peer-reviewed publications using MPMs.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree
8. Papers using MPMs display the MPM in a table or in the supplementary information.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree
9. Given the current state of peer-reviewed publication practice around MPMs, I think a standardized method of MPM reporting is necessary for the coherent communication of MPMs in the literature.
    a. Possible answers:
        i. Strongly disagree
        ii. Disagree
        iii. Neither agree nor disagree
        iv. Agree
        v. Strongly agree

Supplementary Table 1. Corresponding data to include when publishing MPMs along with a rationale for inclusion and examples of good practice.

Data to be presented	Rationale	Examples
GPS coordinates of studied populations	• To match spatial bioclimatic data and climatic projections to population dynamics	• Eckhart et al., (2011) : *Clarkia xantiana* (gunsight clarkia) • Wilson & Martin, (2011): *Lagopus leucura* (white-tailed ptarmigan)
Life cycle diagram	• To visualise the MPM and to validate MPM construction methods and relay the life-history of the organism to the reader	• Weppler, T., Stoll, P., & Stöcklin, J. (2006): *Geum reptans* (geum) • Arnold, Brault, & Croxall, (2006): *Diomedea melanophris* (black-browed albatross) • S. R. Beissinger, (1995): *Rostrhamnus sociabilis* (snail kite) • Brault & Caswell, (1993): *Orcinus orca* (killer whale) • Evans, Ferrière, Kane, & Venable, (2007): *Oenothera californica* (evening primrose)
Projection interval	• To allow projections to be informed by time (*i.e.*, projected over days, months or years)	• Hunter et al., (2010): *Ursus maritimus* (polar bear) • Picó & Riba, (2002): *Ramonda myconi* (Pyrenean-violet) • Van Mantgem & Stephenson, (2005): six coniferous trees
Table of vital rates and generic matrix population model	• To reconstruct the MPM for quality control and ensure the correct inclusion/exclusion of survival in reproductive output • To decompose the MPM into individual vital rates (*i.e.*, to separate survival, growth and reproduction rates that contribute to the same matrix element) • To obtain life history traits and perform vital rate sensitivity analysis that incorporates lower-level parameters	• Greene & Beechie, (2004): *Onchorhyncus tshawytscha* (chinook salmon) • D. Doak, Kareiva, & Klepetka, (1994): *Gopherus agassizii* (desert tortoise)
All individual population projection matrices	• To examine stochastic dynamics • To have full reproducibility of the study results concerning modelled population dynamics and to optimize value for reuse	• Valverde, T., & Silvertown, J. (1998): *Primula vulgaris* (common primrose) • Guàrdia, Raventós, & Caswell, (2000): *Achnatherum calamagrostis* (tussock grass) • Silva Matos, Freckleton, & Watkinson, (1999): *Euterpe edulis* (tropical palm)
Population vector	• To enable transient analyses • To perform population forecast • To determine whether a population is/is not at stable stage distribution	• Krueger, Rutherford, & Mason, (2013): *Onchorhyncus tshawytscha* (chinook salmon) • Hunter et al., (2010): *Ursus maritimus* (polar bear)

	• For Bayesian estimation of matrices and confidence intervals of the parameters	• Esparza-Olguín, Valverde, & Vilchis-Anaya, (2002): *Neobuxbaumia macrocephala* (columnar cactus) • Tremblay et al. (2021): *Lepanthes eltoroensis* (Luquillo mountain babyboot orchid)
Study rationale	• To corroborate the purpose of the methods used in MPM construction and subsequent analysis	• Johnson & Zúñiga-Vega, (2009): *Brachyrhaphis rhabdophora* (live bearer) • Cropper & Loudermilk, (2006): *Pinus palustris* (longleaf pine) • Steven R. Beissinger, (2014): *Cyprinodon diabolis* (Devil's Hole pupfish) • Johnson & Zúñiga-Vega, (2009): *Brachyrhaphis rhabdophora* (live bearer)
Attribution for secondary data sources	• To allow third parties to validate the author's findings from raw data • A Bayesian approach requires explicitly mentioning the priors of the transition, stasis, and survival elements in addition to the reproductive estimates.	• Stratford, Pollino, & Brown, (2016): *Macquaria ambigua* (Golden perch), *Maccullochella peelii* (Murray cod), *Gadus macrocephalus* (Common cod) • Yen, Bond, Shenton, Spring, & Mac Nally, (2013): *Maccullochella peelii* (Murray cod), *Macquaria ambigua* (golden perch), *Hypseleotris klunzingeri* (carp gudgeon), *Retropinna semoni* (Australian smelt) • J. A. Morris, Shertzer, & Rice, (2011): *Pterois miles* (common lionfish) and *P. volitans* (red lionfish) • Kocmoud, Wang, Grant, & Gallaway, (2019): *Lepidochelys kempii* (Kemp's ridley) • Tremblay & McCarthy, (2014): *Lepanthes rupestris* (lithophytic orchid)
Census timing and periodicity	• To determine the time interval the population is being projected with respect to its environment as well as its reproductive schedule • To better match intra-annual climatic events to population dynamics	• McFadden, (1991): *Alcyonium* (alcyonacean soft coral) • Metcalf, Hampson, & Koons, (2007): *Spermophilus parryii* (arctic ground squirrels) and *Connochaetes taurinus* (Serengeti wildebeest) • Yoccoz, Nakata, Stenseth, & Saitoh, (1998): *Clethrionomys rufocanus* (grey-sided vole)
Associated treatments to individual matrices	• To allow for comparative analysis of MPMs informed by treatment type via simulation and life table response experiment (LTRE) analyses	• Peterson, Rieman, Young, & Brammer, (2010): *Oncorhynchus clarkii lewisii* (westslope cutthroat trout) • Bronikowski, Clark, Rodd, & Reznick, (2002) : *Poecilia reticulata* (guppy) • Werner & Peacock, (2019): *Eucalyptus tetrodonta* (Darwin stringybark), *E. miniate* (Darwin woollybutt) and other savanna trees



Supplementary Figure 1. The current workflow for the production and scaling of demographic information using matrix population models (MPMs). We block the workflow into three main sections: “Preparation and data acquisition” for construction of methodologies to lab/field work, “Modelling” for the coercion of data into MPMs, and lastly “Inference” for the interpretation of demographic outputs for current and future publications. Along this workflow, we highlight when potential issues can occur, and where their consequences can emerge in demographic analyses.

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