Influence of Parasitism on Condition Factor of Speckled Dace (*Rhinichthys osculus*)

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Background

- Parasites are widespread in freshwater ecosystems[1], yet are understudied and disregarded in fisheries management.
- Condition factor, an index widely used to estimate fish health, may be strongly impacted by parasitism.
- Objectives**:** use speckled dace from Sierra Nevada alpine lakes to

  (i) characterize parasite prevalence;

  (ii) explore parasite carrying capacity of fish hosts; and

  (iii) study how parasitism affects condition factor.

Methods

- Dissected 92 speckled dace from 10 Sierra Nevada alpine lakes. Measured length and mass of fish (standard length, mm) and parasites (total length, mm).
- Calculated Fulton's Condition Factor (K) (K = 100 * weight / length^3) for every sampled fish before dissection. For parasitized fish, recalculated K post parasite removal.
- Used a linear mixed effect model to compare K between (i) non-parasitized and parasitized fish; and (ii) parasitized fish pre and post parasite removal.
- Modeled parasite carrying capacity using general additive models (GAMs).

Results - Parasite Prevalence

Table 1. Parasitized fish prevalence in Sierra Nevada alpine lakes

Lake*	Sample Size	Parasitized Fish (n)	% Parasitized Fish	Mean Parasites Per Fish**	Mean % of Fish Weight that is Parasite**	% Parasitized Fish with Multiple Parasites**
Black	14	9	64.3	1.89	24.6	44.4
Jewel	14	9	64.3	1.33	21.4	33.3
Triangle	1	1	100.0	1.00	14.1	0.0
Turnaround	13	2	15.4	1.00	28.5	0.0
Big Bear	8	4	50.0	1.25	18.5	25.0
Lower Sardine	7	2	28.6	1.00	16.0	0.0
Lower Salmon	11	0	0.0	NA	NA	NA
Silver	1	0	0.0	NA	NA	NA
Upper Sardine	15	8	53.3	1.88	16.3	37.5
Upper Salmon	8	0	0.0	NA	NA	NA
Total/Avg.	**92**	**35**	**37.6**	**1.34*****	**19.9*****	**20.0*****

* Lakes in green are located in Lassen basin; lakes in blue are located in Lakes basin in Sierra City
** Values calculated only using parasitized fish
*** Total average calculated only on parasitized lakes (NAs were not included)

Results - Carrying Capacity

Figure 1. Photo of parasite removal.

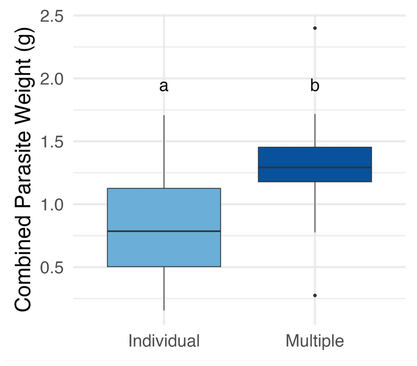
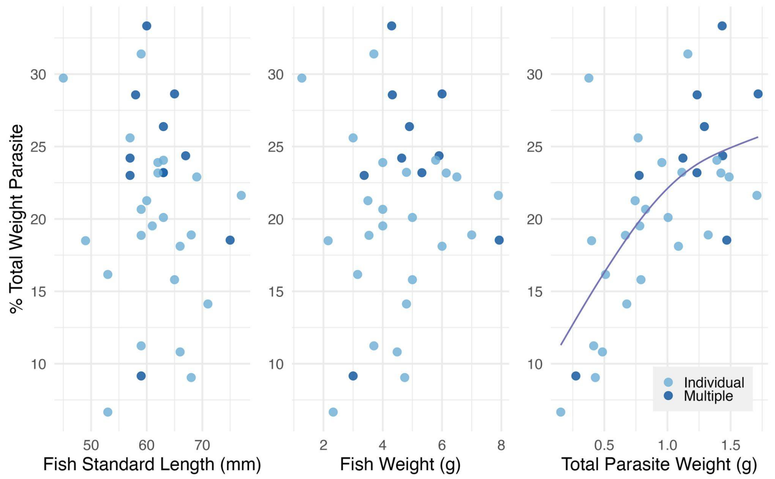


Figure 2. Box plot of total parasite weight (per fish) comparing fish with individual and multiple parasites. Letters denote significance. Boxes denote the median, interquartile range and 95% confidence intervals.

(a) Per fish



(b) Per parasite

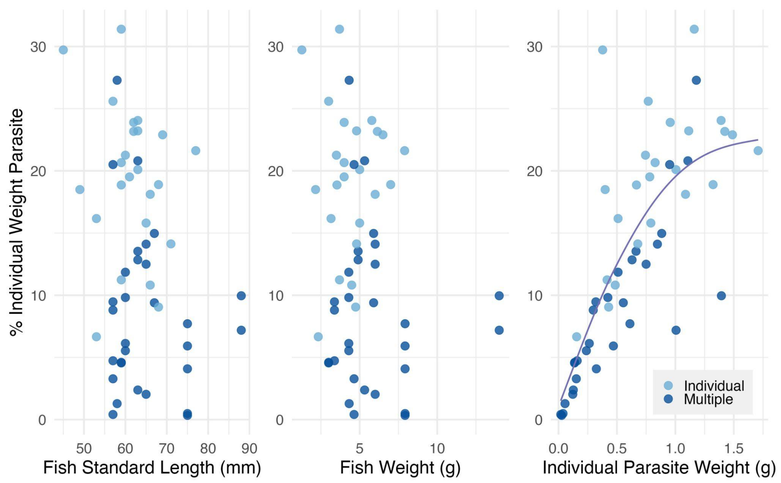


Figure 3. (a) Percentage of total parasite weight (per fish) and (b) percentage of individual parasite weight (per parasite) as function of fish length, fish weight and parasite weight.

Results - Condition Factor

Figure 4. Photos of parasitized fish (a) pre and (b) post parasite removal.

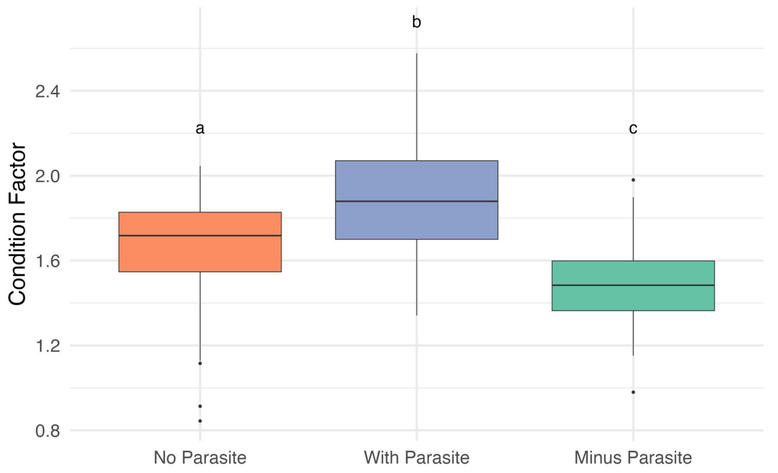


Figure 5. Box plot of condition factor comparing non-parasitized fish and parasitized fish pre and post parasite removal. Letters denote significance. Boxes denote the median, interquartile range and 95% confidence intervals.

Conclusions

- Tapeworm parasites are widespread in Sierra Nevada alpine lakes, but prevalence varies.
- There is an apparent carrying capacity of tapeworms and their fish hosts centered around 26% of fish weight.
- Condition factor is **overestimated** in parasitized fish. As a result, K may not be an accurate indicator of fish health in parasitized populations unless explicitly quantified.

Acknowledgements

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1. Timi, J.T. and Poulin, R. (2020). Why ignoring parasites in fish ecology is a mistake. Int. J. Parasitol 50:10-11, 755-761.