Improving Parasite Transmission Parameters for a Mathematical Model of Swimmer’s Itch
Using Both Empirical and Analytical Techniques

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Introduction

- Cercarial Dermatitis (Swimmer’s itch) is an emerging disease in the Midwest.
- The infection is caused by the parasite Trichobilharzia sp., an avian schistosome that can penetrate human skin.
- The main symptom of the infection is the development ofitchy welts near the site of parasite entry.
- A mathematical model of the Swimmer’s itch can aid in the prediction of future disease transmission patterns.
- However, such a model requires accurate parameters.

Conceptual Model

- Humans are exposed to the parasite through water contact.
- Cercariae penetrate the skin of fish and a cercaria releases cercarial cercariae.
- Cercariae mature in the snail host and release sporocysts.
- Sporocysts hatch to release cercariae, which then infect a new host.

The life cycle of avian schistosomes

![Image 1](https://example.com/image1.png)

Figure 1: The life cycle of avian schistosomes

Improving the Migration Function $\Lambda_i(t)$

The migration function $\Lambda_i(t)$ can be described as:

$$\Lambda_i(t) = \begin{cases} \sin((t/15)\omega) & 0 \leq t \leq 30 \\ 2.39\omega (0.38 - 0.37/\omega)^{30} & 30 < t \leq 90 \\ -2.39\omega (t - 123 - \omega)^{55} & 90 < t \leq 153 \\ \sin((t/15)(t - 153)) & 153 < t \leq 184 \end{cases}$$

Figure 3: Migration rate of birds into the lakes throughout the migratory season

Prevalence of Infected Snails Over Time

![Image 2](https://example.com/image2.png)

Figure 4: A) Physon sp. snail from Devil’s Lake, WI. B) Sporocyst at 400X magnification. C) Trichobilharzia sp. at 400X magnification.

Table 1: List of parameters used in the model and their descriptions.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Lambda_i$</td>
<td>Migrating migration rate (birds/del)</td>
</tr>
<tr>
<td>$\omega$</td>
<td>Sexual probability of egg to adult manger</td>
</tr>
<tr>
<td>$b_{SB}$</td>
<td>Rate of offspring per adult snail per day</td>
</tr>
<tr>
<td>$n$</td>
<td>Mortality rate in manger due to infection</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Transmission rate from $S_i$ to $E_i$</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>Transmission rate from $I_i$ to $E_i$</td>
</tr>
</tbody>
</table>

Table 2: Snails were collected from Devil’s Lake, WI and screened for Trichobilharzia sp. in June 2019. Snails were organized into three disease classes: susceptible, exposed, and infected.

<table>
<thead>
<tr>
<th>Lake</th>
<th>$\omega$</th>
<th>$\beta$</th>
<th>$\gamma$</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higgins</td>
<td>1.98524</td>
<td>10</td>
<td>5.7624</td>
<td>10</td>
</tr>
<tr>
<td>Crystal</td>
<td>1.98524</td>
<td>10</td>
<td>5.7624</td>
<td>10</td>
</tr>
</tbody>
</table>

Figure 5: The genetic algorithm method of parameter estimation

Summary and Conclusions

- Our model was created to estimate infection prevalence in birds and snails throughout the migratory season.
- Screening of infection for snails sampled from Devil’s Lake, WI produced an estimate of initial conditions.
- Behavior of the migration function $\Lambda_i(t)$ was estimated as sinusoidal during the spring and fall and bell-shaped during the summer.
- A genetic algorithm was used to produce estimates for key parameter values.
- Higher prevalence at Crystal Lake can be explained by different transmission rates between infected and susceptible hosts.

Future Directions

- Collect more data on infection prevalence in snails to improve the parameter estimates obtained via the genetic algorithm.
- Gather data on bird and snail populations throughout the summer in order to assess the accuracy of the model.
- Generate specific parameter values for high-risk geographical areas in the Midwest.

Acknowledgements

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References