1. **Results**
   1. *DEBkiss Model*

We obtained realistic fits to the full life cycle data (Figure 2). The only exception is late-life survival, for which the mortality was too high beyond the larval stage but could not be better fit due to lack of full-life survival data. However, this did not impair our ability to model the effects of hypoxia on early life survival. Estimating *yVA* returned a value much lower than 0.8, which is the value suggested by Jager (2018) and has been applied in DEBkiss models of other species (e.g. Jager et al., 2018; Hamda et al., 2019). However, our value of *yVA* =0.365 is close to the maximum growth efficiency of 0.375 measured in the closely related *M. beryllina* (Letcher and Bengtson, 1993). This gave a realistic fit to the length data and allowed a detailed and very close fit to egg buffer mass over time (hatch timing). The observed and predicted data for full life span and early life are plotted in Figure 2.

* 1. *Hypoxia Effects*

Applying the oxygen-dependent correction factor to the parameter combinations listed above reproduced the direction of experimentally observed hypoxia effects, e.g. increasing *JaAm* reduced total length, increased time until egg buffer mass reaches 0, and reduced survival. The best model of experimental hypoxia effects on *M. menidia* early life stages simultaneously had *yVA* multiplied by *c*, and *μemb* and *μlar* divided by *c* (Figure 4, Table 4, Figure S1). Although applying damage to *yVA* alone affected all three state variables, concurrently increasing both mortality parameters improved the fit to the data (Table 4). The model in which the correction factor was applied to *yVA*, *μemb*, and *μlar* also had the lowest AICc of all candidate models, with an AICc of 794.03 (AICcmin). Adding a correction factor to *JvM* in simultaneously with these three parameters yielded a slightly higher AICc of 795.97 (Table 4). The ratio of Akaike weights shows that the model with *c* applied to *yVA*, *μemb*, and *μlar*, is 2.67 times as likely as the one with *c* concurrently applied to *JvM* (Table 4). Applying a damage effect to maintenance was therefore not considered to have improved the fit. After estimating *Z* we calculated the values of *yVA*, *μemb*, and *μlar* when their respective correction factors are applied for each DO level (Table 5).

Interestingly, although *JaAm* affects the variables similarly to *yVA*, the ratio of Akaike weights showed that the best fitting model is about 3000 times as likely as the version applying inhibition to *JaAm*, *μemb*, and *μlar* (Table 4). Reducing *JaAm* with hypoxia using the correction factor resulted in a visually good fit to the data across oxygen levels and variables. Simultaneously applying *c* to *JaAm* and both mortality parameters improved the fit compared to only applying it to *JaAm*, but this model fit less well than the version that applied *c* to *yVA*, *μemb*, and *μlar*, with an AIC value of 810.21 in the former model compared to 794.03 in the latter.

The estimated best value of *Z*, the exponential coefficient in the correction factor *c*, enables us to calculate that *yVA* at the lowest oxygen level is 55% of its value with no hypoxia stress. Reducing conversion efficiencyalone produced small differences in survival at hatching because it prolongs the time spent in the embryo stage, which has a greater mortality rate than post-hatching in our model. Dividing both the pre- and post-hatching mortality rates by *c* more closely predicted the reduced survival rates in the low DO treatments, resulting in a best fitting model that explained observed hypoxia effects well by altering conversion efficiency, embryo mortality, and post-hatch mortality.