Captive-reared migratory monarchs fly in the wrong direction: a critique of Wilcox et al.

Andrew K. Davis

Odum School of Ecology, University of Georgia, Athens, GA 30602, USA

*Corresponding author: Email: akdavis@uga.edu

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Rearing monarch butterflies in captivity for release into the wild is an activity pursued by a growing number of citizens, despite calls from scientists and conservation groups about the risks to the overall population (Monarch Joint Venture, 2018; Pelton, 2018). One of the more well-publicized risks identified thus far is that monarchs raised indoors may be lacking a key developmental feature: reduced navigational sense when harnessed in a flight simulator (Tenger-Trolander et al., 2019; Tenger-Trolander and Kronforst, 2020). This argues that some yet-to-be-identified environmental cue from the outdoors is needed for proper development of migration/navigational ability. Still, some indoor-reared monarchs do successfully reach their Mexico or California destination (Maeckle, 2018; James and Kappen, 2021), which raises the possibility that at least some metamorphosed adults can still regain their orientation sense once on their journey. Wilcox et al. (2021) recently tested this idea using a combination of flight simulator tests and releases of tracked monarchs from their location in southern Ontario. Their simulator tests confirmed that late summer-reared monarchs appear to show random orientation, consistent with prior experiments. They next released some of these monarchs after harnessing them with radio transmitters, which can track animal movement using a novel system of receiving towers called Motus (Taylor et al., 2017). Their results showed that the monarchs travelled in a uniform direction (generously referred to as ‘southerly’ by the authors), and the authors claimed that this is evidence that reared monarchs can ‘regain’ their navigational ability once released. This claim is unjustified, as explained below.

It is true that the monarchs released by Wilcox et al. (2021) travelled in a more-or-less uniform direction (as opposed to random, as in the flight simulator), but importantly, the monarchs’ overall direction was southeast, which is not the direction leading to Mexico from southern Ontario (southwest). In fact, based on bearings of all released monarchs provided in their supplemental file, it is clear that not one monarch from their study showed the correct heading (below; see Fig. 1). This issue is the linchpin of the argument they are making—that reared monarchs have regained their ‘normal’ navigational ability. Of note here is that the authors did not have a control group for comparison that, ideally, would have been comprised of wild-caught migrants, which then would be harnessed with the same Motus tracking devices. If the trajectory of reared monarchs matched that of wild monarchs using this tracking system, then it might be possible to make this claim. Instead, the authors referred to a prior study (using the same tracking system) where a handful of wild monarchs showed a south-southeastern orientation when released at a location 250 km north of theirs (Knight et al., 2019).

The normal direction of travel of migrating monarchs from this region of North America is very clear, based on multiple prior navigational studies conducted from southern Ontario and the surrounding area in the past 40 years (Fig. 1). These include flight simulator tests (Mouritsen and Frost, 2002), vanishing bearings of released migrants (Parlin et al., 2021), direct observations of wild migrants (Schmidt-Koenig, 1985; Gibo, 1986) and even inferred tracks
Figure 1: Comparison of reported flight trajectories of fall-migrating monarchs from the southern Ontario and surrounding region (A). Wilcox et al. (2021) tracked monarchs after outfitting with radio transmitters (B). Parlin et al. 2021 recorded vanishing bearings of captured and released migrants (C). Schmidt-Koenig (1985) observed directions of wild migrants in New York state (D). Mouritsen and Frost (2002) evaluated the navigation of wild migrants from southern Ontario with a flight simulator (E). Gibo (1986) observed migrating monarchs in southern Ontario and recorded flight directions of over 500 individuals (shown here is the mean direction and variance, as reported; F). Finally, monarch travel directions can be inferred from maps of points of origin and recovery of tagged individuals (MonarchWatch, 1997) (G). All compass images redrawn from material presented in cited articles. Except in (F), all lines represent the track of a single monarch. All lines are drawn at the same length, for simplicity.

from tagged-and-recovered monarchs (MonarchWatch, 1997); though tracks drawn from tagging data are not as strong as evidence from direct observations of flight. Taken together, these separate pieces of evidence show that ‘normal’ migration in this region is a southwestward flight, or at the very least, southward—not southeast, which is the direction most of the reared monarchs appeared to travel. The reason(s) for this skewed flight trajectory would need to be examined with further tests, perhaps beginning by assessing the functionality of reared monarchs’ innate internal compass (Nguyen et al., 2021).

Regardless of the navigational issue, another limitation of the study by Wilcox et al. (2021) is the means of tracking the released monarchs; while this tracking system may work well for larger animals (birds, bats), the jury is still out as to whether it is appropriate for insects. The authors state, almost in passing, that the Motus transmitters weigh 200 mg. Monarchs in that region have an average weight of 525 mg (Brindza et al., 2008). The authors stated that they selected monarchs that weighed over 300 mg. In essence then, these monarchs were likely carrying a device that weighed half their body weight. While it is clearly possible for monarchs to achieve flight with this extra weight, as evidenced by the fact that some were detected many kilometers away, it is a stretch to call this ‘normal’ flight, since they would be so burdened. In fact, in the prior tracking study cited to bolster their case, Knight et al. (2019) state ‘Most tagged monarchs could not sustain flight after release and were kept for one to two nights, fed honey–water solution and released in the morning.’ To be fair, it is not clear if this statement implies the monarchs were burdened, or if the tagging was too late in the day for release. Another (newly identified) problem with this transmitter approach is that even the glue used for attachment could affect monarch flight and/or health. Recently, Parlin et al. (2021) evaluated the survival of monarchs that had had rods glued to their cuticle (using similar glue as the study in question) and observed 100% mortality after 5 days. This evidence argues that the procedure for attaching the harness is stressful and/or that the glue itself imparts a significant cost even days after attachment. Thus, given the variety of problems associated with using this tracking system on insects, any conclusions drawn from it (including the study by Knight et al., 2019) must be tempered. For full disclosure, flight mill tests in my own laboratory involve gluing rods to monarchs for attaching to the mill (Davis et al., 2012), but these monarchs are never expected to fly on their own in the wild.

Even if this study’s conclusions were eventually borne out with further tests, the navigational issue is only one of many potential risks identified with captive rearing, such as the fact that reared monarchs show reduced physical strength and have paler wing colour (Davis et al., 2020), which is a known
indicator of poor flight propensity and/or migration success (Davis et al., 2012; Hanley et al., 2013) for monarchs. In fact, a recent re-examination of tag recovery records of reared and wild monarchs showed that migration travel distance of reared monarchs was only one quarter of that of wild individuals (Tenger-Trolander and Kronforst, 2020), which is consistent with reared monarchs having poor flight ability and/or reduced flight strength. Captive rearing also carries risks of spreading disease, which itself is a known detriment to migration success (Bradley and Altizer, 2005). Thus, for Wilcox et al. (2021) to suggest that their results support the idea that captive rearing is a viable conservation strategy to help the monarch migration is a gross overstatement. Moreover, it runs counter to the message being spread by monarch and insect conservation organizations (Monarch Joint Venture, 2018; Pelton, 2018) that argue that the risks of this practice are too great.

Regarding the study by Wilcox et al. (2021), I would argue that these results are preliminary at best and should have been paired with true controls (wild migrants) before submission of this study for publication, and certainly before making claims about the safety of captive rearing for the monarch population. Given the declines in the number of monarchs successfully reaching their winter destination (Agrawal and Inamine, 2018), efforts should be focused on minimizing human impacts on migration ability of the population, not on populating the migratory generation with poor fliers.

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