

Birds vs. Butterflies: Exhibiting Tropical Passerines and Lepidoptera in the Osher Rainforest Exhibit at the California Academy of Sciences

Timothy Wong

Biologist II, Steinhart Aquarium, California Academy of Sciences
55 Music Concourse Drive, San Francisco, CA 94118

The Osher Rainforest exhibit at the California Academy of Sciences houses a mixed species display of birds, butterflies, tropical plants, reptiles, fish, and amphibians in a spherical glass greenhouse. The exhibit was designed to house a diverse and naturalistic selection of species originating from rainforest habitats around the world; providing unique challenges for husbandry staff to successfully display a diverse selection of tropical Lepidoptera with insectivorous Passerine species chosen for exhibit.



Photo 1: Paradise Tanager *Tangara chilensis*



Photo 2: *Heliconius hecale* nectaring

Introduction

Displaying live tropical butterflies successfully with insectivorous birds naturally poses many challenges. Since opening in 2008, the species of exhibit butterflies remained relatively unchanged resulting in regular predation and fewer butterflies on display. In 2017, the exhibit underwent significant renovations to improve how visitors experienced live butterflies, creating opportunities to make changes to husbandry, improve the habitat, and try new species of butterflies at elevated numbers while maintaining compatibility with the existing bird collection. These changes aimed to increase the survivability and maximize the diversity of butterflies on display.

New feeding stations for birds and butterflies were spatially separated, differentiated by color, and varied in diet. This reduced encounters between birds and butterflies while increasing feeding opportunities for both groups. Horticulturists improved the complexity of the exhibit habitat for roosting and increased the planting footprint of nectar resources. We revised the butterfly order structure to increase the overall number of butterflies received for exhibit, increasing the sample size for understanding why some butterfly species failed and others thrived. Identifying that newly eclosed butterflies were frequently targeted by birds, we also revised the butterfly release strategy; newly eclosed butterflies are confined in hampers for an

additional day with food resources before release. This allowed some species to dry their wings for a full 24-hour period, develop more evasive behavior, and encouraged them to fly further below the ceiling of the exhibit where most observed predation encounters occur. Some species which failed to display well prior to changes in the release strategy were then observed to be successful.

Regular predation continues to be observed by Silver-beaked tanagers (*Ramphocelus carbo*) and Yellow-rumped caciques (*Cacicus cela*), which increased during periods of active nesting behavior and chick rearing. Other bird species on display show little to no interest in butterflies as prey, even showing benefits as plant pest control. Ultimately, we worked with vendors to prioritize successful butterfly species that were most compatible with the birds on display.



Photo 3: Exterior view of Osher Rainforest Exhibit



Photo 4: View from canopy level

The Exhibit: The Osher Rainforest is staffed by 6 Biologists with shared roles as horticulturists, lepidopterists, herpetologists, aviculturists, and aquarists. The exhibit comprises of three distinct levels with contained aquariums, reptiles, amphibians, and terrestrial invertebrates. Free flying birds and butterflies have access to the entire exhibit within the glass containment measuring 27.4m (90ft) in diameter and 16.7m (55ft) in height over an open top 100,000 gallon tropical freshwater aquarium. The exhibit receives both natural and artificial lighting primarily from the top of the rainforest where birds and butterflies tend to spend most of their time.

Species Selection and Predation

Bird Species: A variety of bird species were selected that would be active and colorful on display, produce unique songs, and have potential for captive breeding. Biologists considered the natural diet of the chosen bird species, knowing that butterflies would be included in the exhibit. The species housed since opening in 2008 have changed dramatically due to mortality, aggression, breeding projects, or removal from the exhibit. Of the 21 species exhibited, there are 11 currently on display of which only two species show regular interest in consuming butterflies. Displaying insectivorous birds allows us to participate in significant SSP (species survival plan)

captive breeding programs, showcase authentic rainforest species, enrich the display with charismatic songs, and improve plant health through the consumption of plant pests.



Photo 5: *Cyanerpes cyaneus* feeding chicks



Photo 6: *Coereba flaveola* foraging for plant pests

| Common Name | Species | No Predation Observed | Observed Predation | Undetermined |
|-----------------------------|----------------------------------|-----------------------|--------------------|--------------|
| Green and Gold Tanager | <i>Angara schrankii</i> | x | | |
| Blue Ground Dove | <i>Claravis pretiosa</i> | x | | |
| Bananaquit | <i>Coereba flaveola</i> | x | | |
| Yellow-legged Honeycreeper* | <i>Cyanerpes caeruleus</i> | x | | |
| Red-legged Honeycreeper | <i>Cyanerpes cyaneus</i> | x | | |
| Blue Dacnis* | <i>Dacnis cayana</i> | x | | |
| Black-faced Dacnis | <i>Dacnis lineata</i> | x | | |
| Violaceous Euphonia* | <i>Euphonia violacea</i> | x | | |
| Rufous-crowned Tanager* | <i>Tangara cayana</i> | x | | |
| Paradise Tanager* | <i>Tangara chilensis</i> | x | | |
| Blue Necked Tanager* | <i>Tangara cyanicollis</i> | x | | |
| Bay Headed Tanager* | <i>Tangara gyrola</i> | x | | |
| Turquoise Tanager* | <i>Tangara mexicana</i> | x | | |
| Opal-rumped Tanager* | <i>Tangara velia</i> | x | | |
| Swallow Tanager | <i>Tersina viridis</i> | x | | |
| Blue-gray Tanager | <i>Thraupis episcopus</i> | x | | |
| Yellow-rumped cacique* | <i>Cacicus cela</i> | | x | |
| Silver-beaked Tanager* | <i>Ramphocelus carbo</i> | | x | |
| Red-shouldered Tanager | <i>Tachyphonus phoenicius</i> | | x | |
| Yellow-green Grosbeak | <i>Caryothraustes canadensis</i> | | | x |
| Saffron Finch | <i>Sicalis flaveola</i> | | | x |

Table 1: Levels of predation by different bird species on exhibit with butterflies

Predation: We used several resources to evaluate predation of butterflies on display, a difficult task due to the high density of foliage in the exhibit and lack of staff to observe animals outside

of normal work hours. Using binoculars during the day, staff watched bird and butterfly encounters closely. They found that some birds targeted certain species of butterflies, and observed many palatable butterfly species being consumed immediately upon release, or vanishing from the exhibit within a few days. Most predation encounters were observed at the ceiling of the exhibit where butterflies were disoriented by lights and glass became easy prey. Yellow-rumped cacique (*Cacicus cela*) and Silver-beaked tanagers (*Ramphocelus carbo*) were regularly seen predating on all palatable butterfly species, including Blue morphos (*Morpho peleides*) and several small species of longwings (*Heliconius charitonia*, *Heliconius doris*, and *Heliconius sara*) previously thought to be unpalatable. In some parts of the exhibit we found discarded wings that provided a snapshot of which butterflies were being consumed out of view. Observations from staff, photos from guests, and comments from visitors were additional sources of evidence for determining which birds were consuming different species of butterflies. During a four month long exhibit renovation in 2017 which required the removal of all birds, palatable butterflies increased in abundance, suggesting that predation was a significant factor in their success or failure on display.



Photo 7: *Ramphocelus carbo*



Photo 8: *Cacicus cela*



Photo 9: Discarded Butterfly wings



Photo 10: *Ornithoptera priamus*



Photo 11: *Heliconius ismenius*



Photo 12: *Idea leuconoe*

Lepidoptera Species: Many butterfly species were attempted on display with the existing birds, especially those that were thought to be unpalatable and resistant to predation. Of the 35 butterfly species released onto exhibit, 22 species were either rarely or moderately eaten by birds, and 18 species were heavily eaten by birds until they were visually eliminated from the display. Heavily predated species were removed from our regular butterfly shipments. Butterflies which host on poisonous plants families (i.e. Aristolochiaceae, Passifloraceae, Solanaceae, and Apocynaceae) were most successful, often ignored after initially being sampled and then rejected by birds. These species also tend to display strong aposematic coloration, mullerian mimicry, and find suitable roosting sites in our exhibit. We suspect that additional species from the tribes

Heliconiini, Danaini, Ithomiini, and Troidini would be compatible with insectivorous birds and be worth trialing on display in the future.

| Common Name | Species | Rarely Predated | Moderately Predated | Heavily Predated |
|------------------------|-------------------------------|--------------------|---------------------|---------------------|
| Isabella Longwing* | <i>Eueides isabella</i> | x | | |
| Glasswing Butterfly* | <i>Greta oto</i> | x | | |
| Zebra Longwing* | <i>Heliconius charithonia</i> | x | | |
| Red Postman* | <i>Heliconius erato</i> | x | | |
| Tiger Longwing* | <i>Heliconius hecale</i> | x | | |
| Hewitson's Longwing* | <i>Heliconius hewitsoni</i> | x | | |
| Tiger Heliconian* | <i>Heliconius ismenius</i> | x | | |
| Common Postman* | <i>Heliconius melpomene</i> | x | | |
| Sapho Longwing* | <i>Heliconius sapho</i> | x | | |
| Paper Kite* | <i>Idea leuconoe</i> | x | | |
| Tiger Clearwing* | <i>Mechanitis polymnia</i> | x | | |
| Green Birdwing* | <i>Ornithoptera priamus</i> | x | | |
| Common Rose * | <i>Pachliopta kotzebuea</i> | x | | |
| Cattleheart Butterfly* | <i>Parides arcas</i> | x | | |
| Golden Birdwing* | <i>Troides Rhadamantus</i> | x | | |
| Magnificent Owl* | <i>Caligo atreus</i> | | x | |
| Forest Giant Owl* | <i>Caligo eurilochus</i> | | x | |
| Giant Owl* | <i>Caligo memnon</i> | | x | |
| Juno Longwing* | <i>Dione juno</i> | | x | |
| Sara Longwing* | <i>Heliconius sara</i> | | x | |
| Doris Longwing* | <i>Laparus doris</i> | | x | |
| Blue Morpho* | <i>Morpho peleides</i> | | x | |
| Band-celled Sister | <i>Adelpha fessonia</i> | | | x |
| Brassiolis Butterfly | <i>Brassiolis isthmian</i> | | | x |
| Blue Frosted Banner | <i>Catonephele numilia</i> | | | x |
| Red Lacewing | <i>Cethosia biblis</i> | | | x |
| Zebra Mosaic | <i>Colobura dirce</i> | | | x |
| Julia Longwing | <i>Dryas iulia</i> | | | x |
| Forest Mort Blue | <i>Eryphanes polyxena</i> | | | x |
| Cracker Butterfly | <i>Hamadryas arinome</i> | | | x |
| White Morpho | <i>Morpho polyphemus</i> | | | x |
| Blue Wave Butterfly | <i>Myscelia ethusa</i> | | | x |
| Owlet Butterfly | <i>Opsiphanes tamarindi</i> | | | x |

| | | | | |
|--------------------------|----------------------------|--|--|---|
| Giant Swallowtail | <i>Papilio cresphontes</i> | | | x |
| Mormon Swallowtail | <i>Papilio memnon</i> | | | x |
| Green Banded Swallowtail | <i>Papilio nireus</i> | | | x |
| Emerald Swallowtail | <i>Papilio palinurus</i> | | | x |
| Clipper Butterfly | <i>Parthenos sylvia</i> | | | x |
| Orange-Barred Sulphur | <i>Pheobis philea</i> | | | x |
| Malachite | <i>Siproeta stelenes</i> | | | x |

Table 2: Resistance of butterflies to predation by existing birds on exhibit

Husbandry and Exhibit Changes to Improve the Success of Butterflies with Birds

Exhibit updates in 2017 allowed us to implement new feeding strategies, improve the exhibit habitat, experiment with new butterfly species, and practice new butterfly release methods with hopes of improving butterfly survivability on display.



Photo 13: Diets with bird and butterfly food 2008 **Photo 14:** Bird diets on designated plates 2018

Feeding: Prior to exhibit updates in 2017, each feeding station included food for both birds and butterflies. This was offered on plates suspended over the open exhibit from railings by a metal rod and a locking support for the plate. While functional for some species, the set up encouraged predation and competition between birds and butterflies. To reduce encounters between birds and butterflies, diets for birds were separated and offered on plates on the midstory level and in the canopy bird cage. Birds are offered finely chopped fresh fruit, vegetables, an insectivore Mazuri pellet, artificial nectar, and softbill diet twice daily on plates that are yellow, green or brown in color. The birds are also offered a variety of live insects (mealworms, waxworms, phoenix worms, crickets, and flies) which is increased during period of breeding. Butterflies now have several designated feeding stations in the canopy that are prepared with sliced fruit on contrasting red-colored plates for fruit feeding species and large swallowtails. The partitioning of resources greatly improved visitation by both butterflies and birds to their designated feeding stations.

Improving the Exhibit Habitat: Renovations in 2017 also included replanting the entire canopy level of the exhibit; increasing the footprint for growing nectar plants from 1.67 m² (18 ft²) to 6.1 m² (66.2 ft²) allowing us to support the increasing densities of surviving butterflies and improve

the attractiveness of the habitat for butterflies to roost, hide, and feed. Improvements to the habitat on this level dramatically reduced the ascent of butterflies to the glass ceiling where risk of predation is highest.



Photo 15: Butterfly feeding station in canopy



Photo 16: Various *Caligo* sp. at feeding station



Photo 17: Butterfly habitat 2008



Photo 18: Butterfly habitat 2018 with new plantings

Delayed Butterfly Release Strategy and Butterfly Order Size: Despite improved habitat and food resources for butterflies, newly eclosed Blue morphos and several *Heliconius* sp. continued to fall prey to existing birds, particularly just after release. We frequently observed new butterflies instinctively ascending to the ceiling when released where predation by birds was swift. After observing these events, we decided to revise our butterfly release strategy. After eclosing in our emergence cabinet, all butterflies are now held in hampers with food, delaying release until the following morning. Biologists felt this might give vulnerable species extra time to fully dry their wings and develop a sense of “alertness” that might aid in evading predators. We observed changes in behavior in multiple species of butterflies after implementing this strategy, which has seemed to improve overall success. Upon release, longwings flew directly to flowers than upwards, while larger species were more likely to a roost or perch. Prior to these changes, we had no success with Blue Morphos (*Morpho peleides*) or Zebra Longwing butterflies (*Heliconius charitonia*). From 2008-2017, biologists received an average of 100-125 pupa for display each week. The relatively small sample size of butterflies made it difficult to determine if species which appeared to perform poorly on display were simply being eaten or if there were too few of them to observe in the exhibit. We now receive an average of 325 pupa

every two weeks. Increasing the overall number of butterflies in our orders for display gives us a larger sample size to determine which butterflies are successful.



Photo 19: Newly eclosed butterflies in emergence cabinet



Photo 20: Butterflies held overnight

Conclusion

Housing insectivorous birds and butterflies in a mixed species display is a challenging and evolving proposition. While it may reduce the diversity of Lepidoptera that can be displayed successfully, there are many species of insectivorous passerines that can be highly compatible with butterflies. In addition to visual appeal, free flighted birds can bring benefits of improved plant health, and enrich displays with their charismatic songs. Through specific husbandry changes, habitat improvements, and careful vetting of species, we have been able to successfully meet exhibit and guest expectations while maximizing the compatibility between our tropical Lepidoptera and existing insectivorous Passerines. These observations may provide insight for other exhibitors aiming to recreate a naturalistic representation of rainforest habitats through the inclusion of birds and butterflies. We will continue working with butterfly suppliers to trial new species of Lepidoptera, particularly from unpalatable tribes (Heliconiini, Danaini, Ithomini, and Troidini) to increase the diversity of animals in our mixed species display.

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