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The Live Butterfly Trade as Bio-business In Southern Mexico

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Abstract

The live butterfly trade presents significant opportunities for sustainable development on the Yucatán Peninsula, but data on the current state of businesses in this field are scarce and unsystematized. Using the non-probabilistic snowball sampling technique, we interviewed critical actors in this industry, including the personnel of butterfly houses and butterfly farms, technical experts, and scientists. Results allowed us to construct an overview of these bio-businesses' main obstacles and challenges, improve our understanding of key technical and regulatory difficulties, and document that Mexican bio-businesses rely on extensive knowledge from breeders and exhibitors. The article also analyzes the degree to which federal regulators and local government provide or omit supervision of, and support for, the sustainable development of this activity and encourage or discourage its potential contributions to environmental education and the dissemination of science.

Keywords: butterfly house, butterfly farm, bio-business, trade study

Le commerce des papillons vivants en tant que bio-entreprisedans le sud du Mexique

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Résumé
Le commerce de papillons vivants présente d'importantes opportunités de développement durable dans la péninsule du Yucatan, mais les données sur l'état actuel des entreprises travaillant dans ce domaine sont rares et non systématisées. À l'aide de la technique non-probabiliste d'échantillonnage en boule de neige, nous avons interrogé des acteurs critiques de cette industrie, notamment le personnel des serres à papillons et des fermes à papillons, des experts techniques et des scientifiques. Les résultats nous ont permis de construire une vue d'ensemble des principaux obstacles et défis rencontrés par ces bio-entreprises, d'améliorer notre compréhension des principales difficultés techniques et réglementaires et de documenter le fait que les bio-entreprises mexicaines s'appuient sur les connaissances approfondies des éleveurs et des exposants. L'article analyse également dans quelle mesure les régulateurs fédéraux et les gouvernements locaux fournissent ou omettent de superviser et de soutenir le développement durable de cette activité et encouragent ou découragent la contribution potentielle de ce secteur à l'éducation environnementale et à la diffusion de la science.
Mots-clés : serre aux papillons, ferme aux papillons, bio-entreprise, étude commerciale

1.0 Introduction

Butterfly breeding is a field of business that supports local economic development and diversification through the rational management and conservation of tropical forests in rural communities (New, 1994; Orozco, 2005; Centro de Inteligencia sobre Mercados Sostenibles, 2006). The butterfly trade has two main currents: the breeding of live butterflies for release at social events and display in butterfly houses, and the production of stuffed butterflies for arts and crafts activities, collectors, and scientific research. This paper focuses on the first type of trade, the commercialization of large, colorful live butterfly species because of their great visual appeal. Zoos and botanical gardens purchase specimens and display them as important attractions, but this activity also opens opportunities for education on environmental care by promoting a deeper understanding of insect diversity and its importance for ecosystems (Clark & Landford, 1991).

In 2000, the world market value of sales of butterflies and related products surpassed $100 million in U.S. dollars (Boppré & Vane-Wright, 2012). Although there is no way to systematically validate this figure, companies dedicated to commercial butterfly breeding in countries like Venezuela, Costa Rica, Colombia, Peru, and Ecuador (Jaffé et al., 1992; Torrealba & Carbonell, 2002; Constantino, 2006; Arias, 2013; Vásquez et al., 2017) have proven to be viable and successful. In Mexico, poor social organization in rural areas, scant economic incentives, and the legislation governing these businesses have been identified as serious obstacles to market development, despite the fact that many butterfly species there have high economic potential (González et al., 2011) and are generating interest in butterfly breeding for sale and exhibition in various regions. Jacinto-Padilla et al. (2017) identified 17 butterfly species in the Tabasco and Yucatan Peninsula ecosystems that have commercial and ornamental potential. Coincidentally, these are regions of high tourism interest with important cities and archaeological sites, such as Mérida and Chichen Itzá in Yucatán, Cancún and the Riviera Maya in Quintana Roo, Calakmul and the Rivers Route in Campeche, and the Usumacinta Canyon in Tabasco.

At the national level, Xcaret Park in Quintana Roo was the pioneering locale for butterfly exhibitions in the 1990s. Since then, butterfly houses have opened in zoos and botanical gardens. However, data are lacking to determine when breeding for commercial purposes began. In south and southeast Mexico, this activity has emerged in rural areas around Tenosique, Tabasco; San Pablo Etla, Oaxaca; and Boca Chajul and Bonampak, Chiapas (Gonzáles & Pérez, 2015). Today, the live butterfly trade is an alternate source of income for those communities, where it is strengthening local economies and promoting greater awareness of the need to conserve and protect natural resources (Warman, 1996; Dénommée, 2010; Pérez, 2018; Gonzáles & Pérez, 2015). Sadly, existing data are insufficient to estimate the success of this business in Mexico.

The only market study of the financial feasibility of a butterfly house created for eco-tourism purposes was conducted in the state of Colima in western Mexico (Lomelín, 2012). Since there are no related studies in the southeast, we were interested in exploring the following research questions: What is the current state of the live butterfly market in southeast Mexico?, and how have breeders there positioned themselves in regional markets? Our aim was to design a market study based on interviews with representative actors that will improve our understanding of the current conditions and realities of butterfly breeding by (1) characterizing producers and exhibitors; (2) identifying the type(s) of consumers in Mexico; and (3) clarifying how this productive activity contributes to generating income at the local level.

2.0 Type of Establishments that Sell or Exhibit Live Butterflies

Butterfly farms are operations dedicated to the breeding, reproduction, and conservation of butterflies in all stages of their life cycle (Bendaña, 2017). They then sell their products to butterfly houses or private parties for release at social events. Butterfly houses are establishments dedicated primarily to the exhibition and preservation of various species of live butterflies outside their natural habitat. These sites provide controlled conditions of temperature, humidity, light, and sustenance that mimic the natural habitat of these insects.

The entire breeding and display process is under human control (Torrealba & Carbonell, 2002). Butterfly houses and farms fall into the category of bio-trades or bio-businesses, based on the principle that all products and activities derived from the exploitation of biodiversity must collect, produce, transform, and trade in ways that respect both the surrounding community and the environment (United Nations Conference on Trade and Development, 2020). Bio-business encompasses commercial activities that emphasize the importance of the life sciences and related processes (Guptha & Nagrath, 2023). Breeding butterflies requires a deep understanding of their biology and associated biotic conditions, while their commercialization, as we will show, also entails specialized knowledge.

Bio-trade businesses must observe the principles of corporate social responsibility and ensure that mutually beneficial, harmonious relations exist between producers and buyers, regardless of the amounts invested or company size. Unfortunately, the data currently available in Mexico did not allow us to determine whether breeding and exhibition businesses there really take these principles and responsibilities into account. For this reason, we argue that they are best considered as bio-businesses. Ideally, companies that breed and sell butterflies would operate on the principles of social, environmental, and economic sustainability, and recognize the responsibilities that these entail (Camacho, 2015).

2.1 Legal regulations for trading living butterflies in Mexico

The laws and regulations established to govern the breeding of butterfly species in Mexico are issued by the General Directorate of Wildlife, an agency of the Ministry of the Environment and Natural Resources (DGVS and SEMARNAT, for their acronyms in Spanish). Parties interested in trading live butterflies must comply with regulations SEMARNAT-08-055 (registration of the butterfly house's technical manager) and 08-004 (registration of an organization related to conservation and sustainable wildlife use). Breeding and exhibition companies should operate in a regulated, legal manner to ensure support for their activities and adequate monitoring of internal operations on their wildlife breeding farms (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, 2020).

3.0 Materials and Methods

We began our study by reviewing the literature on national and international commercial butterfly breeding and exhibition sites and bibliography on business organizations that focus on wildlife use and exploitation. We then registered butterfly houses and butterfly farms in the study area and invited their personnel (by telephone and social media) to answer a survey on *Google Forms*. We used the non-probabilistic snowball sampling technique to identify informants (Goodman, 1961), a method that consists in contacting additional respondents in each round based on recommendations by the initial

interviewees. The first individuals we approached were suggested by a scholar who specializes in butterflies. From May 2020 to February 2021, we applied two semi-structured, initial questionnaires. The first included 36 questions and was designed for breeders. The second, for use with butterfly houses, had 43 questions. Both instruments were structured in six blocks: (1) general data, (2) services offered and demand for butterflies, (3) costs and means of distribution, (4) links between buyer and seller, (5) internal and external challenges of their business model, and (6) business performance.

After applying the surveys in March 2021, we conducted six complementary, qualitative, semi-structured interviews by video call, using a list of 22 questions. In this stage, we interviewed two people from each of the following sectors: (a) research centers or academic institutions that train people interested in butterfly breeding and/or butterfly house management, (b) employees of butterfly houses involved in scientific dissemination and environmental education (EE), and (c) butterfly breeders outside the study region. Interviewees thus included people from different regions of Mexico who were asked to speak on four central topics: (1) experiences in technical support of butterfly house management, (2) the role of educational institutions and scientific dissemination as tools for developing capacities, (3) laws and regulations, and (4) social and economic perspectives on breeding and exhibition (see Table 1).

Table 1. *Complete List of Informants*

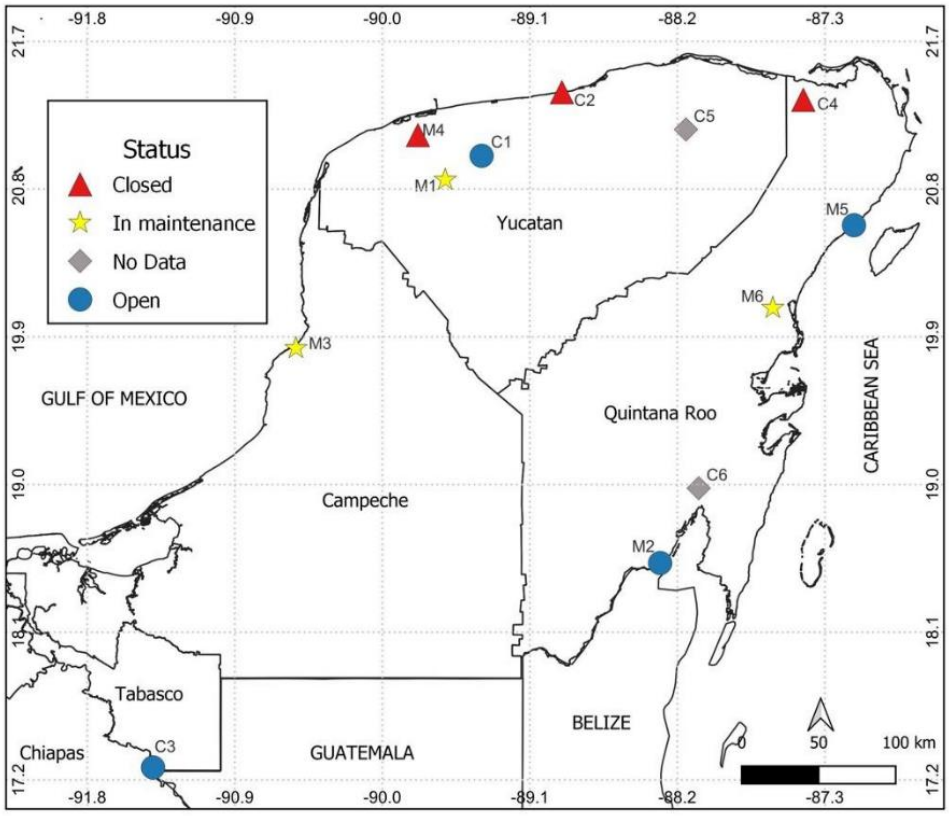
ID	Name	Type of informant	Type of establishment	Role or position	Working experience (years)	Location*
1	Pedro	Pr	BF	P	15	C1
2	Griselda	Mk	BF	P	5	C2
3	Noel	TA	BF	P	10	C3
4	Alejandrina	Pr	BF	P	7	C4
5	Any	AM	BH	Ex	3	M1
6	Damaris	AM	BH	Ex	5	M2
7	Víctor	Gd	BH	Ex	5	M3
8	Jana	AM	BH	Ex	3	M4
9	Juan	Cm	BH	Ex	25	M5
10	Román	Gm	BH	Ex	8	M6
11	José	EC	BH	E	10	CDMX
12	Guillermo	AM	BH	E	18	CDMX
13	Luis	Pr/ Mk	BF	E	15	Yucatán
14	Javier	Pr	EI	E	25	CDMX
15	Noemí	SR	RC	E	30	Q. Roo
16	Carmen	SR	RC	E	30	Q. Roo

Abbreviations: BH: butterfly house; BF: butterfly farm; EI: educational institution; RC: research center; Pr: producer; Mk: marketer; TA: technical advisor; AM: area manager; SR: scientific researcher; EC: educational curator; Cm: coordination and monitoring; Gm: general manager; Gd: general direction; P: production; E: expert; Ex: exhibition; CDMX: Mexico City.
*For 1-10, see location in Figure 1.

We then transcribed and coded the information from the interviews to develop a qualitative analysis. The next step was to create an information grid segmented into textual fragments according to the thematic axes of the second round of interviews, complemented by data from the first surveys. After that, we conducted a thematic-interpretative analysis of each case accompanied by a frequency analysis to analyze the behavior of the live butterfly market in the study area. Finally, we used the information from the initial interviews to develop a scheme that represents the market situation. This allowed us to address key aspects of the sale of butterflies by breeders in southeast Mexico and the relations between sellers and some buyers.

Another aim of our work was to describe the product life cycle (Levitt,1965), from the conception of the commercial project, through its launch into the market, up to the most recent relevant moment (Godás, 2006). We considered the biological cycles of each butterfly species reproduced on farms and their flight times in order to better understand the time, costs, and work involved in breeding for commercialization and the maintenance of specimens in the butterfly houses. The study spanned sites in the states of Tabasco, Campeche, Yucatán, and Quintana Roo (see Figure 1) that, together, represent 8.31% of the country's land surface. Productive activities in this region depend largely on the state of conservation of native flora and fauna (Armijo et al., 2015). The main economic activities are agriculture, extractive operations, commerce, transportation services, and tourism, mainly oriented toward the northern Yucatan Peninsula (Sarmiento & Castellanos 2010; Pat & Cantún, 2010).

Figure 1. Location of butterfly houses (M1-6) and butterfly farms (C1-6) within the study area.



Source: B. R. Prado-Cuéllar

4.0 Butterfly Houses and Butterfly Farms in Southeast Mexico

Personnel from six butterfly houses and six butterfly farms in the study area were invited to answer the online survey. We received responses from all six houses, but only four farms, since two did not answer (see Figure 1). All establishments are private businesses with a specific legal status that subjects them to certain legal regulations (see Table 2). One unexpected initial finding was that each company had filed distinct legal documentation for its operations, but we were unable to pinpoint why this occurred when, in fact, it is quite easy to comply with the existing regulations for registering a Management Unit for Wildlife Conservation or Installations for Wildlife Management (UMA and PIMV, for their acronyms in Spanish). C1 has authorization from the Finance Ministry and the UMA permit, but farm C3 and butterfly houses M4 and M6 operated without any regulatory documentation. We further found that the states where these bio-businesses are registered apply the laws differently, a reality that hinders the functionality of regulatory programs. The responses show that the decision-makers require constant training to determine the best course for running their operations—houses or farms—but find it difficult to exchange experiences. In Mexico, the butterfly species *Danaus plexippus, Papilio esperanza*, and the moth *Rhotschildia cincta*, are subject to special protection (NOM-059-SEMARNAT-2010) (Diario Oficial de la Federación, 2019; The IUCN Red List of Threatened Species, 2020-22), but only the first is included among the species bred for commercialization and requires special permits granted by the aforementioned agencies. One farm breeds *D. plexippus* without the required permit because, we were told, its application to SEMARNAT went unanswered, so they opted to assume the risk of continuing their work without them.

4.1 Overview of the Initial and Complementary Interviews

All staff members of the butterfly farms said they performed the following activities: collecting wild specimens for breeding, breeding, maintaining nutritional plants for the larval and adult stages, supervising flight and laboratory areas, and sales. In contrast, the activities of the butterfly house employees varied with the area to which they were assigned: administration/supervision, supply chain, or procurement, among others. All the managers and administrative personnel at these houses and farms received basic training to perform their functions: formal studies in biology or a related field, and complementary courses or workshops. They also mentioned independent, individual training. In addition to breeding and selling, they performed numerous tasks related to environmental protection and education.

Two butterfly houses display butterflies year-round, while others do so only during holiday periods. Several houses lack the budgetary resources to purchase the specimens they wish to exhibit, so they turn to (a) ***ex-situ* breeding**, that is, intensive captive breeding that requires infrastructure to supply nutritional plants for larvae and adults; (b) **ranching**, based on a combination of *in situ* and *ex situ* breeding; and (c) **capture of wild specimens**. We were unable to determine the approaches utilized in two cases: M4 did not provide information on acquisitions, while M6 only mentioned how it acquired butterflies to begin the project.

Table 2. *Data from Butterfly Houses and Farms in Southeast Mexico*

Business	**ID***	**Location**	**Approach**	**Status**	**Official documents for operating**
Butterfly farm	C1	Tixcocob	VEV	ACT	UMA and Treasury registrations
	C2	Dzilam de Bravo	VEV	INA	UMA
	C3	Tenosique	GOES	ACT	WD
	C4	Solferino	EXH	INA	UMA
	C5	Tizimin	SD	SD	SD
	C6	Mahahual	SD	SD	SD
Butterfly house	M1	Xmatkuil	EXH	EM	UMA and PIMV
	M2	Chetumal	EXH	ACT	SD
	M3	Campeche	EXH	EM	SEMARNAT permits
	M4	Sierra Papacal	INV	INA	WD
	M5	Playa del Carmen	EXH	ACT	EM
	M6	Muyil	EXH	EM	WD

Abbreviations: VEV = sale of live specimens; EXH = exhibition; INV = research; VA = sale of handicrafts; ACT = active; INA = inactive; EM = in maintenance; SD = no data; WD= without documents; EMP= environment management plan.
*For 1–10 see location in Figure 1.

These butterfly houses maintain relations with their peers by exchanging specimens and management experiences. M1, M2, and M3, originally funded by municipal or state resources, do not conduct any fundraising activities beyond exhibitions. Most interviewees mentioned understaffing, low budgets, diseases affecting the pupae and butterflies, and deficient pest control as the most important factors that negatively impact their operations. Follow-up interviews added comprehensive, up-to-date information on the live butterfly trade and observations from regional production experts, exhibitors who disseminate science through their knowledge of butterflies, and staff from academic centers specializing in tropical butterflies. Information from the initial and complementary interviews was used to create the initial market study outlined below.

4.2 The Live Butterfly Trade in Southeast Mexico

Several butterfly species, in either the pupae or adult stage, are traded in the study area. Over 85% are from the *Nymphalidae* family. They are especially popular due to their large size, rich genera, abundance, and physical attributes that make them attractive to visitors at exhibition sites. Producers sell directly to customers and set their own rates, from $0.25-4.37 (all prices in U.S. dollars). Species with the highest adult-stage lifespan are the most sought-after and, not surprisingly, the most expensive types, due to the time invested in breeding. In contrast, there is an oversupply of common species whose breeding times are relatively short, so prices tend to be low to ensure they will be sold. Producers may refuse to sell to potential clients who want to buy butterflies for release at an event but show no regard for the natural distribution of a particular species. In the words of one expert:

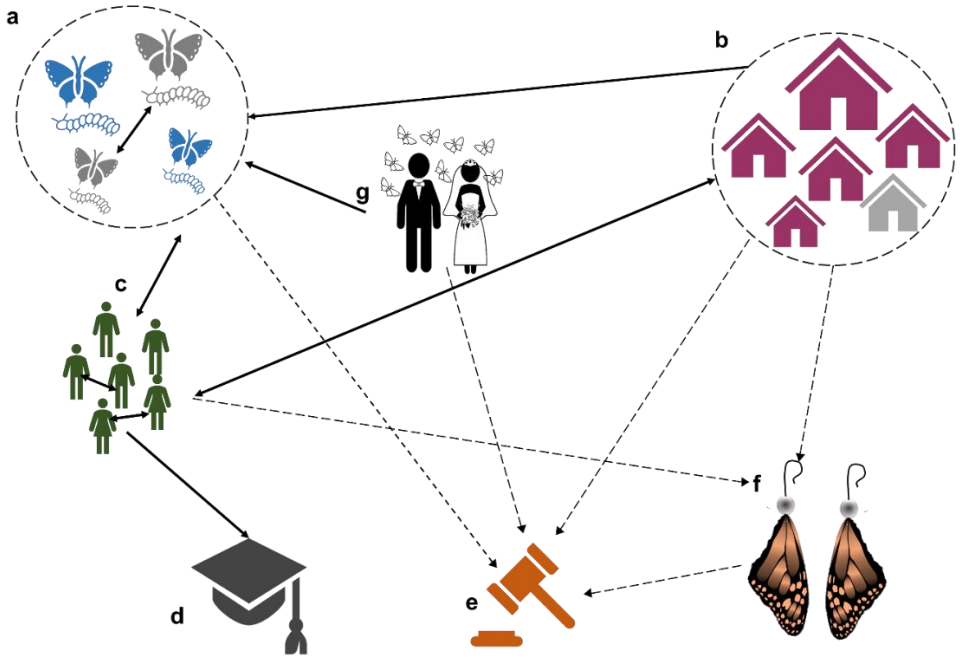
> You must avoid taking butterflies from one state to another if they are not neighbors. For example, suppose I want the blue butterfly (*Morpho*) from Oaxaca or Yucatán to take it to Tijuana to be released at an event. In that case, it is complicated because it's not a native species… even more difficult is importing butterflies for release. This [activity] is only for butterfly houses (Javier, technical expert in butterfly house management, training, and commercial production, Mexico City. Personal communication, July 27, 2021).

At present, releasing butterflies is a popular feature at many social events (see Figure 2-g), but these insects are also ordered in large quantities for exhibition in butterfly houses to attract local and foreign tourists (see Figure 2-b). The main consumers of living butterflies, then, are butterfly houses and people who wish to release them at social events. Butterfly houses attract visitors of all ages and income levels due to their accessible entrance fees, which rarely exceed $2.50. To attract more visitors, they may offer discounts to local schools. Our interviewees indicated that the butterflies they offer can be acquired by people from distinct economic backgrounds, but we were unable to gather the data required to analyze buyers' behavior to support this affirmation. Some marketing experts state that cultural, religious, economic, and social factors directly influence buyers' decisions (Delgado et al., 2018), so we suggest that future research on this subject include analyses of these aspects.

The main challenges mentioned by the representatives of these companies were shortages of key resources, inadequate planning, inadequate facilities, and a lack of contingency plans to deal with unexpected conditions, such as hurricanes or floods. One of the informants' comments:

> In Dzilam they requested support for training, breeding and sale. The Technological Institute of Conkal provided everything necessary to make the butterfly house, but later, due to planning problems to carry out its implementation... they ended up closing it (Luis, independent producer and seller of live butterflies, Yucatán. Personal communication, March 6, 2021).

Figure 2. Map of actors and interactions.



NOTE: (a) Butterfly farms; (b) butterfly houses; (c) experts; (d) research; (e) government; (f) arts and crafts sector; and (g) buyers. ---- > weak link, — strong link. Interactions among actors in the live butterfly trade in the study region are simple compared to those that characterize the supply of live tropical butterflies to Europe and North America (Boppré & Vane-Wright, 2012; Rich et al., 2014).

In some cases, project unviability resulted from a lack of access to clean water. Disputes among founders, inadequate technical knowledge to eradicate or control predators in flight areas, poor follow-up by trainers and mentors, and a lack of commitment by communities to promote exhibition spaces were other important causes of project failure. The following comment from an informant is an example of this:

> We did not commit to sales because we ran out of plants for the butterflies due to a lack of water. The four of us who were part of the project dug two wells to obtain water… but they both dried up. We tried everything to carry on because we liked the project. We obtained land from the *ejido* and funding from [various] institutions. Still, we eventually ran out of money, and the *ejido* asked us for the land back (Alejandrina, former producer and exhibitor of live butterflies, Quintana Roo. Personal communication, January 21, 2021).

Other difficulties included the distance from the butterfly house to tourism areas, limited road access, and deficient marketing, while sites that depended on state or municipal resources also had to deal with administrative issues:

> The butterfly house is inside the zoo, so when it's closed (for example, now because of COVID-19), there are few resources and staff for the butterfly

> house, because they move people to "high priority" areas, such as large animals. Insects aren't a priority (Damaris, butterfly house employee, Quintana Roo. Personal communication, January 13, 2021).

These excerpts from our interviews reveal an urgent need for better strategic planning. According to these sources, the average time that a new butterfly farm requires to attract clients is three years, a period consistent with the time it takes to position a business in the live butterfly market. However, continued activity for three years by no means guarantees success, as this is also contingent upon the dynamics of supply and demand. One measure that can be taken to avoid business failures is to diversify the services offered and turn to breeding species not currently available on the market. For example, competition in Colombia has pushed breeders to diversify and begin to sell arts and crafts, including stuffed butterflies mounted for exhibition (Constantino, 2006). However, diversification entails increasing the workload of butterfly house and farm managers, so it may function better as a side business that may foster opportunities to build alliances with local artisans.

5.0 Supply and Demand in the Live Butterfly Trade in Southeast Mexico

Fourteen species of butterflies are currently bred on the Yucatan Peninsula for commercial purposes. They are distributed in ten genera and three families: 12 species of the *Nymphalidae* family, and one each of the *Pieridae* and *Papilionidae* families (see Table 3). The popularity of the *Nymphalidae* can be attributed to four characteristics: (1) broad species diversity, (2) beautiful coloration, (3) attractive size, and (4) exotic shapes (Constantino, 2006). Moreover, they feature exceptional biological adaptiveness, including a long flight period, consumption of various plant strata, and several strategies for evading predators (Vargas-Zapata et al., 2011). The availability of these butterflies in the market depends on such conditions as the time of year, farm location, and the breeder's capacity to offer adequate volumes.

Table 3. *Supply and Demand of Butterfly Species in Southeast Mexico*

Family	**Species**	**Supply**	**Demand**	**Jacinto-Padilla et al., 2017****
Papilionidae	*Battus polydamas polydamas* (Linnaeus, 1758)	X	X	
	Battus philenor philenor (Linnaeus, 1771)		X	
	Papilio thoas autocles Rothschild & Jordan, 1906		X	X
	Papilio cresphontes Cramer, 1777		X	
Nymphalidae	*Agraulis vanillae incarnata* (N. Riley, 1926).	X	X	
	Anartia jatrophae jatrophae (Linnaeus, 1763)		X	

Table 3 continued

	Anartia fatima fatima (Fabricius, 1793)		X	
	*Anaea aidea** (Guérin-Méneville, [1844])		X	
	Caligo telamonius memnon (C. Felder & R. Felder,1867)	X	X	
	*Caligo uranus** (Herrich-Schäffer, 1850)		X	
	Danaus plexippus. plexippus (Linnaeus, 1758)	X		
	Danaus gilippus thersippus (H. Bates,1863)	X	X	X
	Dryas iulia moderata (Riley, 1926)	X	X	
	*Dryadula phaetusa** (Linnaeus, 1758)		X	X
	Hamadryas februa ferentina (Godart [1824])	X	X	
	Hamadryas guatemalena (H. Bates, 1864)	X		
	Hamadryas julitta (Fruhstorfer, 1914)	X		
	Heliconius erato petiverana (E. Doubleday, 1847)	X	X	X
	Heliconius charithonia vazquezae (W. Comstock & F. M. Brown, 1950)	X	X	X
	*Morpho helenor peleides** (Kollar, 1850)	X	X	X
	*Prepona pheridamas** (Cramer, 1777)		X	
	Siproeta stelenes biplagiata (Fruhstorfer, 1907)	X	X	X
Pieridae	*Ascia monuste* (Linnaeus, 1764)	X		
	Phoebis sennae sennae (Linnaeus, 1758)		X	

*Species bought overseas. **Reported by Jacinto-Padilla et al., 2017.

The butterfly house managers we interviewed mentioned 20 species distributed in 15 genera and three families: 15 species of *Nymphalidae*, four of *Papilionidae*, and one of *Pieridae* (see Table 3). They bought ten from the breeders in the region, four overseas, and one (*M. helenor peleides*) bought in Mexico and overseas. We could not determine how the species *B. p. philenor, P. thoas autocles, P. cresphontes, A. j. jatrophae, A. f. fatima,* and *P. s. sennae* were acquired. *A. monuste* was reported as the species most often bought for release at social events. Interviewees recognized five species as having the highest demand: *Heliconius charithonia, Siproeta stelenes, Caligo telamonius*, *Morpho helenor*, and *Battus polydamas*. Some houses buy large quantities of specimens overseas because regional and local breeders can only sometimes provide the required species and amount. Reasons for this emerged during our interviews:

> We know [some] Mexican breeders, but none comes even close to the breeding capacity of Costa Rica. They breed various species, but quantities are insufficient to supply our butterfly house or any other one in Mexico or the world. Despite national efforts to replicate the Costa Rican model, there's been little success. It seems that the bottleneck is due to the production of host plants (Guillermo, butterfly house manager, Mexico City. Personal communication, March 3, 2021).

Consumers in the study area tend to make their major purchases in three periods: Easter (March-April), summer vacations (July-August), and throughout the winter (November-February). These periods match the times of greater tourist flows to zoos, gardens, and parks in the areas where the houses are located.

Regarding prices, our interviewees did not provide the historical data (except C1) that would have allowed us to elaborate an analysis with solid numerical predictions for the balance between supply and demand, or perspectives for future demand. Although breeders offer a variety of species at standard national prices, they are not always able to produce the amounts requested by exhibition spaces. We found that this may be due to a lack of trained staff, poor infrastructure, or the lack of equipment that is essential for optimizing this activity. Whatever the cause, this limited production capacity creates problems for buyers.

Live butterflies are generally sold in packs of 10, rarely by unit. Butterfly farm C3 is dedicated solely to breeding specimens for the arts and crafts market. From 2019 to 2021, its standard price was $3.15, though species like *M. helenor peleides* and *C. telamonius memnon* may sell for up to $4.37. Other butterfly farms (e.g., C2 and C4) sold all species at $1.21, while prices at C3 ranged from $0.49-0.97 for small butterflies, $1.46 for medium-sized specimens, and $2.43 for large species. These price variations reflect the type of species, breeding times, season, distance from the butterfly house to the farm, and specimen quality. Prices are quite similar to those in Costa Rica, which range from $1.50-4.00 per pupa, contingent on species (Constantino, 2006). The most coveted species, including Blue Morpho, can reach prices as high as $4.50, almost double that of more common types (Díaz & Ávila, 2002). Asian species, in contrast, may cost only $1.00, while neo-tropical species sell for around $2.50 (Mulanovich, 2007).

Peak production times vary at each farm, but in all cases, April is the best month for local sales. Breeders should take ethical considerations into account to establish fair, competitive prices, while consumers should buy only from breeders who comply with all legal regulations governing their commercial operations and guarantee that all pupae sold will be replaced. Butterfly house M1 purchases specimens year-round, but the others buy only sporadically. When for some reason they cannot obtain the stocks required, they may breed butterflies on site. Farm C1 is the most popular supplier among the houses on the Peninsula and in nearby regions. An essential number of their transactions occur when clients recommend farms, even though they may not benefit directly from their recommendations. Finally, to complete their transactions, breeders must have access to a reliable service that guarantees delivery of the product to buyers in optimal conditions.

We believe that one bottleneck develops due to specimen shortage, since at the time of study only one breeder was operating. Of course, if clients stop buying for any reason, breeders face serious challenges, Obviously, owners regard closing their businesses as a last resort, but during our interviews, we received comments like the following:

> This is not a 'get-rich' scheme. Many do this for passion, for 'love of the art', because while conditions may not be ideal and they sometimes lose everything, they start over from scratch to continue their projects (Guillermo, butterfly house manager, Mexico City. Personal communication, March 3, 2021).

> It's important not to see everything from a purely monetary perspective. [You have] to toughen up and be patient because economic maturity comes in the long run. It's important to persevere and resist to achieve success (Luis, independent breeder and live butterfly trader, Yucatan. Personal communication, March 6, 2021).

Two of the farms continued breeding insects until financial pressures forced them to shut down. Later they found ways to keep their businesses running by supporting and disseminating scientific research, motivated by a desire to share the importance of butterflies with the public, but, unfortunately, this strategy also failed, and they had to close their doors due to financial insolvency.

One final, critical problem that the live butterfly trade faces is that market prices have remained static, although production, delivery, and staffing costs all continue to rise, not only in Mexico but worldwide (Rich et al., 2014).

5.1 Overview of Legal Support for the Sale and Display of Live Butterflies

The issuing and subsequent enforcement of regulations for the operation of butterfly houses and farms vary widely in Mexico. New (1997) indicates that because the legislation enacted to protect these economic activities is often complex and costly, businesses often simply ignore it. Below, we share some testimonies from our interviewees on the aspect of regulations at the local, regional, and national levels:

> Ideally, you'd have a transport permit, but many don't. The main obstacle to exporting is bureaucracy [for] you need permits from 15 different agencies. It's harrowing. Customs agents place obstacles [and] raise costs [because] they set their fees, in reality, forcing us to abandon [the activity]. It's very discouraging (Luis, independent breeder-trader of live butterflies, Yucatan. Personal communication, March 6, 2021).

> I don't think there's any coherence in how permits are regulated because compliant people are constantly supervised by authorities, while noncompliant breeders operate entirely unregulated (José, manager of a butterfly house with educational objectives, Mexico City. Personal communication, March 4, 2021).

These comments suggest that there is an area of opportunity for the competent authorities to improve the application of the laws and regulations governing this area of wildlife management. There is a critical need to review omissions in the law, clarify issues of corporate responsibility, and improve liaison among all participants in this commercial system: from breeders and exhibitors to public policy officials, the scientific community, and the general population. There is also a clear need to continue efforts to enhance environmental protection of the species of plants and animals bred for commercial purposes, not just butterflies, as New underscores (1997). For example, some species are classified as protected, but no measures are taken to protect their habitat. Finally, studies demonstrate that "weak relationships between the different agencies responsible for the application of legal frameworks on wildlife, both internally in each country and internationally, allow wildlife crimes to flourish" (Reuter & Mosig, 2010).

5.2 National and Regional Trade in Live Butterflies in Southeast Mexico

Pupae are delivered in boxes protected internally with cotton or styrofoam to prevent damage due to shifting, but adult insects are transported in ventilated containers that contain sufficient food for the duration of the journey and allow air to circulate. The boxes used for adults usually have cotton-soaked lining and are supplied with sugary water to ensure that the butterflies will survive the trip. These boxes may be made of cardboard, paper, or natural fibers.

In Mexico, this commercial activity is costly and requires great effort. According to Rich et al. (2014), it is imperative to be intimately familiar with knowledge and research on the value chains that make up this bio-trade, especially the characterization of the actors involved, the economic organization on which the different productive activities are based, and linkages to conservation efforts and environmental protection. Recently, some breeders have added value to their products and services by delivering specimens in high-quality boxes and containers, accompanied by information cards that stress the benefits of buying butterflies from a certified butterfly farm. Butterfly houses and farms market their services largely through social networks, mainly *Facebook* and official websites, but other marketing efforts include print advertising and participation in fairs and exhibitions. Some

projects have received support from municipalities. Our findings show that most sales are conducted in the state of Quintana Roo.

Only one of these butterfly farms (C1) distributes to the entire Yucatan Peninsula. One house (M1) has bought specimens from farms in the states of Veracruz and Puebla, as well as from countries like Guatemala and Belize. At the regional level, butterflies come from farms in Quintana Roo and Yucatan, while internationally, they arrive mainly from Costa Rica. There are no known substitutes or similar products to those provided by butterfly houses and farms. However, there are complementary services, such as workshops and environmental education courses that focus on the importance of butterfly conservation in the areas where they are bred or exhibited. In this regard, Boppré and Vane-Wright (2012) stress that ensuring effective contributions to species conservation through environmental education requires that all pedagogical activities be carefully planned, adding that it is essential to include such topics as basic biological aspects of species and ecological processes, implications for environmental conservation, and collaboration with local conservation initiatives. In this sense, we found that the personnel in charge of handling and operating butterfly houses and farms have excellent knowledge and experience in all aspects related to the breeding and display of these insects. However, communication among them is limited due to trust issues and the fear that their business practices could be replicated by competitors.

Support networks are invaluable because they help create opportunities for the scientific and academic sectors to develop useful knowledge for several of the professional fields that participate in different ways in the live butterfly trade, including pedagogy, environmental education, economics, and social development. The only comparable case to the live butterfly trade involving live insects is commerce in edible insect species, a field that has been analyzed more amply due to the need to address problems of worldwide food supplies (García, 2018).

Another important feature of the live butterfly trade is that it depends fundamentally on economic and social aspects like the capacity for community self-management and knowledge of each species in relation to conservation. In general, businesses that handle insects for commercial use reveal deficits in regulations on production, commercialization, and the standardization of exploitation procedures (Ramos-Elorduy et al., 2006). In contrast to edible insects, one of the most significant advantages of the global live butterfly trade is that these insects are used extensively as a kind of "flagship commerce" to develop educational and sensibilization strategies related to environmental conservation. On this topic, Morris (1987) and Morris et al. (1991) wrote that the butterfly trade emerged as attitudes began to change regarding environmental issues in general and insects in particular (Boppré & Vane-Wright, 2012). We feel strongly that ethical considerations and respect for all living beings should always be given high priority in all businesses, regardless of their specific nature. In this vein, we recommend that all participants in projects in the live butterfly market be willing to continue their training, and to promote close relations with experts in this field and assume an informed bio-business approach.

Other obstacles mentioned in our interviews included poor specimen management, inadequate maintenance of houses and farms, and negative attitudes among the personnel. These factors damage the public image of these businesses, the organizations they represent, and the live butterfly trade in general. Thus, we believe that the companies that trade in live butterflies can follow the lead of other

initiatives that participate in the exploitation and commerce of natural resources by applying a "Four-Propeller" approach based on reaching goals by establishing links among academic institutions, government, business, and civil society (Herrera et al., 2019, p. 349).

5.3 Links and Interactions Among the Actors Who Participate in the Live Butterfly Trade in the Study Region

Figure 2 shows the actors who participated in the live butterfly trade in the study area and their interrelationships. Most interviewees stated that they maintain commercial links to support their activities of buying and trading live and stuffed butterflies, to plan the creation of additional hatcheries, and to provide training for staff. They also expressed the belief that these links are essential for the adequate development of businesses dedicated to the breeding and display of live butterflies. In Figure 2, the authors rate the qualitative links from strong-to-weak according to Granovetter, who stated, the amount of time, emotional intensity, intimacy, and reciprocal services (1973, p. 1361). As these sentences appointed in bold:

> Total transparency among the interested parties is essential… for creating trust… it's how they can develop a **mutually beneficial link**. **Constant communication** through every possible means (calls, emails, visits) and follow-up on each project, even when they've finished… (Noemí, technician and trainer in tropical butterfly topics at an educational institution, Quintana Roo. Personal communication, February 25, 2021).

Constant, **high-quality communication** between breeders and displayers is essential and is now easier, thanks to social networks and technology. However, ongoing collaboration is necessary for proper project follow-up at each stage and for opening the doors to **mutual benefits** among people involved in the sale and display of butterflies in the study area, as the following comments affirm:

> As this communication formalizes, we can obtain more information and better training to improve cash flows and specimen handling (José, butterfly house coordinator, Mexico City. Personal communication, March 04, 2021).

> Involving these spheres (academia, breeders, displayers) is very important… often, we (breeders, butterfly houses) don't have access to academic databases to better handle the species we manage… much of that literature is not accessible to us… (Javier, technical expert in training, butterfly house operation, and commercial production, Mexico City. Personal communication, July 27, 2021).

Finally, our interviewees indicated that butterfly breeding and trading present both significant challenges and attractive opportunities for regional breeders to broaden their commercial frontiers on various territorial scales. It is important to emphasize that the networks that evolve among participants in this trade are highly beneficial

for developing and sharing knowledge about market dynamics. Clearly, however, much remains to be done to draft and enact effective laws and regulations in Mexico, and to ensure compliance with the rules governing international exports. It would be wise, then, for the live butterfly industry to conduct networking with conservation NGOs, educators, and scientists who, in turn, must recognize their responsibilities toward this bio-industry (Boppré & Vane-Wright, 2012).

6.0 Conclusion

There are six butterfly houses and four butterfly farms of economic and ecological interest in the study region that manage butterfly species representative of the Yucatan Peninsula. Currently, the initial consumers in this market come from the same area where butterflies are bred and displayed. The establishments in southeast Mexico that produce and exhibit these insects operate with few employees, under severely constrained economic conditions. Municipalities have supported some projects for the display of butterflies on the Peninsula but have failed to provide adequate follow-up and ongoing support. At present, no level of government provides financial or logistical support to these butterfly breeders.

To date, our work on this bio-trade has generated knowledge of the vision, goals, work experiences, and technologies of the actors involved, but many key issues remain to be addressed, such as understanding how value chains operate, as this would help improve the financial organization of these activities. The live butterfly trade is a complex business model that requires knowledge in different areas, including biology, administration, and education. Academic institutions must strengthen their relationships to support or work in bio-business, and government agencies must work in optimized communication to facilitate the approval of the needed permits.

The need for more efficient communication among participants in the live butterfly trade in southeast Mexico is due mainly to their status as competitors. It is essential to overcome these rivalries, develop links that will open opportunities to improve market conditions and market positioning, and ensure that all links are based on ethical principles and mutual respect. Current relationships, which can be developed over time, will improve the live butterfly trade market throughout the study area.

It is also important to note that the acquisition and trade of exotic species is restricted to purposes of exhibition, never for the release of specimens, since in the medium term this could affect the health of wild specimens in the environment where release occurs and, in the long term, could lead to exotic species dominating native ones. In Mexico and other nations that import and export live specimens, there must be full awareness of, and respect for, the zoosanitary filters imposed in each country or region, so they know in advance which species can be exported for release or for exhibition only.

Our study has some limitations. First, it was conducted during the early months of the COVID-19 pandemic, so we had limited mobility in terms of holding additional interviews. Second, the companies dedicated to purchasing and commercializing butterflies are located in remote communities with limited access to telecommunications (mobile phone or internet service for video calls). Third, the number of establishments that commercialize and/or exhibit live butterflies in the study region is small. Fourth, the confidentiality in the handling

of client lists by producers to prevent competitors from contacting other consumers of live butterflies –for example, for social events– restricted the data we could collect.

We observed that most of the businesses we approached lacked comprehensive planning. In fact, only two (C1 and M6) manifested this activity, and they are the only ones that have remained operational regardless of economic difficulties. We further found that although these two operations are currently self-sufficient, efforts are required to improve the regulatory framework within which they are forced to work.

In closing, this paper contributes to our understanding of the live butterfly bio-business in a specific region of Mexico, thus complementing global research, like the study by Bopreé et al. (2012), that has had a profound impact on our current understanding of the breeding, trading, and networking strategies in southeast Mexico designed to create local and regional operations that will foster expansion into the international sphere. Future studies should focus on broadening our comprehension of the practices and interests involved in this branch of commerce, and the ethical aspects of the consumers of live butterflies, of the dealers who promote their release, and of the conditions under which this commerce operates.

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