

“Value and benefit distribution of pollination services provided by bats in the production of cactus fruits in central Mexico”

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1 **Highlights**

- 2 • Bats are vital pollinators of the pitaya, an important cash fruit crop in Mexico
- 3 • Our valuation approach combines exclusion experiment, yield and value chain data
- 4 • Bat pollination improves the size and yield of the pitaya and thus cash incomes
- 5 • Benefits of ~US\$2,500/ha support rural livelihoods but mainly accrue to some actors
- 6 • Our novel valuation approach provides a basis for other crops and pollinators

7 **Abstract**

8 Despite providing important ecosystem services in both natural and agricultural systems in the
9 tropics, bats are often disregarded or considered pests; and research quantifying their importance as
10 pollinators is scarce. We quantified the value and benefit distribution of bat pollination in the
11 production of a major fruit crop in Mexico (pitayas, *Stenocereus queretaroensis*). We used exclusion
12 experiments to quantify the effect of bat pollinators on crop yield and quality. We then used yield
13 analysis to assess the market value of pollination services, combined with value chain analysis to
14 assess the distribution of these economic benefits among actors. Bat pollination services to pitaya
15 production are worth approximately US\$2,500 per ha through increases in both fruit yield and size,
16 with bats contributing around 40% of gross income across producers. Participation in the pitaya
17 value chain provides a key seasonal source of cash income at a time of low agricultural activity,
18 supporting livelihoods and household activities of the rural poor. However, the commercialisation of
19 the pitaya has concentrated economic benefits with privileged groups who have access to land and
20 markets. Our novel approach to valuing pollination services is transferable to other crops and
21 pollinator species to demonstrate disaggregated socio-economic consequences of losing pollinators.

22

23 **Keywords:** cash crop; columnar cactus; economic valuation; ecosystem services; *Leptonycteris*;
24 value chain; *Stenocereus queretaroensis*

25 **1. Introduction**

26 Pollinators provide many benefits to humans, improving food production and security, and
27 underpinning biodiversity and crucial ecosystem functions (Potts et al. 2016a). Nearly 90% of
28 flowering plants are reliant on animals for pollination (Ollerton et al. 2011), with three quarters of
29 leading global crops, particularly those that are richest in micronutrients, showing increases in
30 production or quality when pollinated by animals (Eilers et al. 2011; Klein et al. 2007; Potts et al.
31 2016b). Bats pollinate many plants of high socio-economic value across the tropics (Kunz et al.
32 2011). However, bat populations are threatened in many parts of the world, with 80% of bat species
33 requiring research or conservation attention (Frick et al. 2019), and the value of bats to the
34 maintenance of ecosystems and human wellbeing is largely underestimated (Kingston, 2016).

35 The quantification of ecosystem service benefits in monetary terms is frequently used to support
36 biodiversity and ecosystem conservation, though it is a complex and challenging issue, particularly
37 where services are intangible and cannot be valued through existing markets (Adams, 2014; Hanley
38 et al. 2015; Breeze et al. 2016). However, the economic valuation of pollination services, such as the
39 direct contribution of pollinators to commercial crop production and quality, can be a useful
40 mechanism to alert decision-makers to the consequences of losing pollinators (Hanley et al. 2015).
41 Existing assessments of pollination services have either focussed on the economic importance of
42 insect pollinators, primarily honeybees (Gallai et al. 2009; Winfree et al. 2011; Hanley et al. 2015) or
43 have established the role of bats as pollinators of tropical crop species, such as durian and fleshy
44 fruits of columnar cacti (e.g. Ibarra-Cerdeña et al. 2005; Bumrungsri et al. 2009; Aziz et al. 2017).
45 To our knowledge, none have directly valued the effects of bat pollinators on yield and quality of a
46 commercial crop in economic terms (though see Sheherazade et al. 2019 for a rough estimation of
47 the value of bat pollination to durian production in Indonesia).

48 One important issue is that, worldwide, ecosystem service benefits – including those of pollination
49 services – are not distributed equitably between different social groups (Hassan et al. 2005). Rural

50 and traditional populations in poor areas are often more dependent on ecosystem services for their
51 livelihoods and will be disproportionately affected by declines in pollinator populations (Hassan et
52 al. 2005; Kumar, 2012). Subsistence or smallholder farmers are less likely to have the economic
53 power to switch to different crops if production fails, or to replace free wild pollinator mediated
54 services with bought services (Morton, 2007). At the same time, the ecosystem service benefits to
55 different stakeholders depend on many socio-economic factors, such as market accessibility, land
56 rights, and opportunity costs of labour and land (Shackleton et al. 2008). While access to ecosystem
57 services can have an equalising impact on rural households, where there are constraints to access,
58 some groups may be further marginalised (Kamanga et al. 2009). There is a considerable gap in the
59 literature concerning the distribution of ecosystem service benefits across different stakeholders,
60 particularly in Latin America; and a subsequent need for disaggregated analysis to identify
61 constraints and improve access (Carpenter et al. 2006; Daw et al. 2011; Breeze et al. 2016; Laterra et
62 al. 2019).

63 This paper uses the pollination by bats of an important cash crop in Mexico, the pitaya (*Stenocereus*
64 *queretaroensis*) as a case study. Bats in the *Leptonycteris* genus are the principal pollinators of *S.*
65 *queretaroensis*, enhancing both yield and quality of the pitaya crop (Tremlett et al. 2019).
66 *Leptonycteris yerbabuenae*, the lesser long-nosed bat, and *L. nivalis*, the greater long-nosed bat, are
67 species of nectar-feeding migratory bats distributed from Central America to the southern U.S.A.
68 (Cole & Wilson, 1996). They are important pollinators of columnar cacti and agaves throughout their
69 range, which play keystone ecological roles in arid ecosystems by providing structural resources,
70 nutrients and water for a variety of animals (Frick et al. 2014).

71 The two main goals of this study are to a) quantify the value of pollination services to the pitaya
72 sector in the most important production centre, and b) assess how these economic benefits are
73 distributed between different actors throughout the pitaya commodity chain. Increased awareness of
74 the economic importance of the contribution of bat pollination services may enable local

75 communities and decision makers to take appropriate actions to ensure the protection of bat
76 pollination services. A greater understanding of how these benefits are distributed intends to inform
77 how future policies can enable more equitable access to, and participation in, the pitaya chain.

78 We use a direct yield analysis approach to estimate changes in both crop yield and quality between
79 open pollinated and pollinator-excluded pitaya crops, and use current market prices to value these
80 changes. Yield analysis is particularly useful for assessing benefits of pollination services at a local
81 level, directly capturing the benefits of pollination services to a crop and differences between
82 cultivars (Breeze et al. 2016; Potts et al. 2016b). However, only benefits accruing directly to the
83 producer are measured using this method. We therefore use value chain analysis to assess how the
84 economic benefits are distributed among different actor groups, affecting livelihoods and wellbeing
85 more widely (Bolwig et al. 2010; Schaafsma et al. 2014).

86 A value chain describes the system and processes that occur along the chain of the production of a
87 commodity and is often used to identify inequalities and constraints in the chain, particularly from
88 the perspective of weaker actors (Kaplinsky and Morris, 2001; M4P, 2008; Meaton et al. 2015).

89 Assessment of profits earned is a useful mechanism to identify barriers in the chain, as greater
90 barriers to particular roles result in higher profits (Kaplinsky and Morris, 2001). However, it is also
91 important to evaluate the returns to labour earned by different actors in the value chain. The poor
92 must often work long hours to meet household needs, indicating ‘time poverty’ even where daily
93 income is sufficient to provide wellbeing (Bardasi and Wodon, 2010). In this paper, we use survey
94 and interview data to assess how income is distributed among actors using distribution of profits and
95 hourly wages as indicators of inequality. We then assess the constraints faced to access more
96 profitable roles and suggest potential mechanisms to encourage fairer participation in the chain by
97 actor groups.

98 2. Study system

99 2.1 Study site

100 In Mexico, 85% of all cultivated plant species are at least partly dependent on animal pollinators;
101 this, combined with high poverty levels and population densities, means that pollination services are
102 crucially important to a large component of the population (Ashworth et al. 2009). Most columnar
103 cacti (Cactaceae) are highly dependent on bats for pollination, including all 22 members of the
104 *Stenocereus* genus, which have been widely utilised for fruit production in Mexico since pre-
105 Hispanic times (Casas et al. 1999; Kunz et al. 2011). However, pollinating bat species continue to be
106 threatened in Mexico by land use and climate change, mining, and disturbance at roost sites
107 (Zamora-Gutierrez et al. 2018; Frick et al. 2019).

108 Techaluta de Montenegro is one of the most important areas for the commercial production of the
109 pitaya, the fruit of *Stenocereus queretaroensis*, a species of arborescent columnar cactus endemic to
110 central-western Mexico (Ibarra-Cerdeña et al. 2005; Pimienta-Barrios and Nobel, 1994). Home
111 garden cultivation of *S. queretaroensis* has occurred since the late 1800s, while intensive commercial
112 production of pitayas began in the 1970s (Pimienta-Barrios, 1999). Low input requirements of water,
113 fertilisers and pesticides result in a substantial financial return (Pimienta-Barrios, 1999).
114 Additionally, the tolerance of *S. queretaroensis* to drought and poor soils, as well as the production
115 of fruit in the dry season when other crops are scarce, make it a sustainable crop in the arid
116 production area (Pimienta-Barrios and Nobel, 1994).

117 The municipality of Techaluta de Montenegro has an area of 79 km² (Mejía Rodríguez, 2012), nearly
118 40% of which is used for agriculture (INEGI, 2009). The main crops by registered volume (tonne)
119 produced in Techaluta de Montenegro are alfalfa (13726 t), hay/pasture (4496 t), maize (3173 t),
120 pitaya (719 t), avocado (700 t), sorghum (484 t) and squash (329 t) (SIAP, 2018). The pitaya
121 generates the highest price per tonne of any crop grown in Techaluta de Montenegro, generating
122 approximately Mex\$19,200 / US\$998 per tonne (SIAP, 2018). Registered pitaya production is

123 expanding yearly, increasing by 71% from 420 t in 2003 to 719 t in 2018 (SIAP, 2018). This growth
124 is driven by an increase in area under production (56 ha registered in 2003 to 86 ha in 2017; SIAP,
125 2018). Figures for both pitaya production and value are underestimates however, as much production
126 is not officially registered with the government.

127 **2.2 Pitaya value chain**

128 The key stages in pitaya production are cultivation, processing (harvesting, peeling fruits, making
129 products), marketing, and consumption. Pitaya production in Techaluta de Montenegro is dominated
130 almost entirely by small commercial plantations and home gardens (Pimienta-Barrios, 1999). The
131 value chain is short, due to the high perishability of the fruit (fruits must be eaten within one to two
132 days of harvest) and subsequent localised market (Pimienta-Barrios, 1999). Most fruits are sold
133 fresh, but a small but increasing proportion is used to make products. Producers largely sell fruits
134 directly to the consumer, either at the roadside or at a market. Actors commonly have multiple
135 functions in the value chain, and the use of intermediaries (defined here as an agent that buys fruit
136 from producers to sell to vendors) is rare (see Supporting Information S1 for a more detailed
137 overview of the stages in the pitaya chain).

138 **3. Methods and data collection**

139 We conducted our fieldwork in Techaluta de Montenegro (20.074°, -103.550°) during 2016 and
140 2017. Section 3.1 summarises the exclusion experiments we carried out to generate empirical data on
141 changes in yield and fruit size between openly pollinated and pollinator-excluded pitaya crops. Next,
142 we collected quantitative production and marketing data from 61 pitaya producers (Section 3.2). We
143 combined these data to estimate the economic value of bat pollination to the pitaya sector in
144 Techaluta de Montenegro (Section 3.3). Then, to assess the distribution of economic benefits
145 resulting from bat pollination services, we analysed economic data collected through structured
146 interviews with a sample of representatives from each actor group involved in pitaya production
147 (Sections 3.2. and 3.4).

148 **3.1 Effect of bat pollinators on pitaya crop yield and quality**

149 We carried out exclusion experiments in 2016 to estimate crop yield under several pollination
150 systems, whereby different flowers were exposed to certain pollinators using bags of different mesh
151 sizes placed during the day or at night. This method has been used to determine effective pollinator
152 taxa in many columnar cacti species in Latin America (e.g. Molina-Freaner et al. 2004; Ibarra-
153 Cerdeña et al. 2005). Bags made from a very fine mesh excluded all pollinators, and bags made from
154 2 cm² mesh excluded vertebrate pollinators but allowed insects. Six different treatments allowed us
155 to distinguish between diurnal vertebrate pollinators, diurnal insect pollinators, nocturnal vertebrate
156 pollinators, nocturnal insect pollinators; with open (all pollinators had access to the flower) and
157 closed (no pollinators had access to the flower) pollination controls. We studied wild individuals of
158 *Stenocereus queretaroensis* (n = 30), as well as three different cultivars chosen for their economic
159 importance: Blanco (n = 22), Mamey (n = 30) and Tenamaxtle (n = 27). We placed each treatment
160 on a separate flower on each cactus individual. We monitored flowers under each pollination
161 treatment and recorded fruit set, then harvested fruits after a standardised number of days (52, 57, 54
162 and 52 days for Blanco, Mamey, Tenamaxtle and wild fruits, respectively) and weighed them. We
163 used estimates from a binomial generalised linear mixed effects model to calculate the probable
164 increase in fruit set with bats relative to diurnal pollinators for each cultivar and for wild cacti (for
165 details, see Tremlett et al. 2019).

166 **3.2 Data collection: economic valuation and value chain analysis**

167 We identified actor groups involved in the production of pitayas in Techaluta de Montenegro using
168 semi-structured interviews with key informants, people previously identified to have expert or broad
169 knowledge about the pitaya production sector (Newing, 2010). During the production season in
170 2017, we collected contact details of potential participants from each actor group by approaching
171 actors at random in both the production area (Techaluta de Montenegro) and subsequent market areas
172 (e.g. Guadalajara). We also used a snowball sampling technique whereby existing participants were

asked to recommend other potential participants. Additionally, we randomly approached registered producers from a list of 189 provided by the municipality.

We then conducted structured interviews, using a standard set of pre-prepared interview questions (Appendix B). We asked participants for: characteristics of pitaya plantations and harvest; marketing and fruit prices; a detailed breakdown of financial costs and time spent on pitaya-related activities by both family members and employees; and details of socio-economic background. These topics were selected so we could fully determine aspects of income for each actor group (Kaplinsky and Morris, 2001; M4P, 2008; Sanogo, 2010). To validate responses, we asked each respondent several questions relating to total and monthly income, prices and profits. Interviews allowed accurate data collection while allowing participants privacy to discuss personal issues (Newing, 2010). We carried out pilot interviews in a neighbouring production town (Amacueca) in June 2017 to check and refine interview questions.

We carried out 124 interviews between July and August 2017. Interviews were conducted by trained volunteers and lasted between 40 minutes and 3 hours. Prior to starting the interview, we provided details of the project, data storage, and issues relating to anonymity and confidentiality, and obtained written consent from each participant. We had ethics approval from the University of Southampton ethics committee prior to carrying out data collection.

3.3 Economic valuation

To estimate the economic value of bat pollination V_b in pitaya production, we used a production value method (Winfree et al. 2011), which estimates the value of bat pollination assuming that there are no substitutes. This economic value is estimated using the following general model:

$$V_b = D \cdot P \cdot Y \quad (\text{Eq. 1})$$

where V_b is the economic value of bat pollination in pitaya fruit production, D is the crop's dependency on bat pollination (i.e. the fractional reduction in crop yield or quality in the absence of

197 bat pollinators), P is crop price (expressed in Mex\$ per fruit) and Y is crop yield (in fruits per
 198 producer).

199 Our exclusion experiments showed that bat pollination affects both fruit yield (Y), and fruit quality,
 200 in terms of size (Q). Thus, there are two separate elements to the crop's dependency on
 201 pollination: D_{yk} and D_{qkw} . We derived D_{yk} from the mixed effects model parameter estimates (see
 202 Section 3.1), indicating the difference between pitaya fruit set when bats were excluded (diurnal
 203 pollinators only) and fruit set with bats present, which varies across pitaya types k . We derived D_{qkw}
 204 from empirical data collected on changes in fruit weights in the absence of bat pollinators in
 205 exclusion experiments (see Sections 3.1 and 3.3) and the subsequent impact on price, which varies
 206 across producers w and pitaya type k . Hence, V_b has two additive components:

$$207 \quad V_b = V_{yb} + V_{qb} \quad (\text{Eq. 2})$$

208 where V_{yb} is the value of the fruit yield attributed to bat pollination (Eq. 3); and V_{qb} is the value of
 209 the fruit quality attributed to bat pollination (Eq. 4).

210 To calculate the value of the fruit yield attributed to bat pollination for each producer, we multiplied
 211 the proportion of fruits produced of each pitaya type ($\frac{Y_{kw}}{Y_w}$) by the crop yield dependency specific to
 212 each pitaya type (D_{yk}). We then summed the change in fruit yield across pitaya types and multiplied
 213 this proportion by the gross revenues from selling pitaya fruits (V_w). To calculate V_{yb} , we then
 214 summed the value of the change in yield attributable to bats across all pitaya producers (W) in the
 215 study area, i.e.:

$$216 \quad V_{yb} = \sum^W \left(V_w \cdot \left(\sum^K (D_{yk} \cdot \frac{Y_{kw}}{Y_w}) \right) \right) \quad (\text{Eq. 3})$$

217 Y_{kw} was inferred from total fruit production reported by the producer multiplied by the proportion of
 218 the cultivar/wild cacti under production.¹ The value of V_{ybw} therefore varies across producers,
 219 depending on each producer's total fruit production for each pitaya type (Y_{kw}), as well as their gross
 220 revenues from selling the fruits (V_w). We assumed an equal price for all fruits sold by each producer
 221 (i.e. the proportion of fruits sold per variety was taken as a proxy for the proportion of revenues per
 222 variety), as we did not have data on the number of fruits sold per producer in each price category or
 223 per cultivar. In reality, prices received by producers varied according to both fruit size and time of
 224 season; however, as producers sold the bulk of their fruits during the peak season for one price, and
 225 had fruit production dominated largely by one pitaya type (and therefore of a similar size), we deem
 226 this assumption defensible.

227 To calculate the value of the fruit quality attributable to bat pollination for each producer, we
 228 multiplied proportion of cacti produced of each pitaya type ($\frac{Y_{kw}}{Y_w}$) by the crop quality dependency
 229 specific to each pitaya type and producer (D_{qkw}). We then summed the change in fruit quality across
 230 pitaya types (K), and multiplied this proportion by the value remaining after subtracting the value of
 231 fruit yield attributable to bats from gross revenues from pitaya sales, $V_w - V_{ybw}$. To calculate V_{qb} , we
 232 then summed the value of the change in quality attributable to bats across all pitaya producers (W) in
 233 the study area, i.e.:

$$234 \quad V_{qb} = \sum^W ((V_w - V_{ybw}) \cdot (\sum^K (D_{qkw} \cdot \frac{Y_{kw}}{Y_w}))) \quad (\text{Eq. 4})$$

235 We assigned a null value for unstudied cultivars for both increase in fruit yield and size, which
 236 accounted for 13% of cacti under production overall.

¹ The inference was necessary because producers were unable to provide estimates of the total production or revenue per cultivar or the quantity sold per size (and thus price) category. For each producer, our dataset included: total quantity of fruits sold, gross revenues, number of cacti under production per cultivar, and average prices per fruit size (small, medium, large) and time in season (start, peak, end).

237 To calculate D_{qkw} , we first collected data on the size of ten fruits in each of the small, medium and
 238 large size bands sold by the roadside in Techaluta de Montenegro in June 2018 to calibrate the
 239 weight ranges of fruits in different price categories. We then compared the proportion of fruits in
 240 small, medium and large size bands under the nocturnal and diurnal pollination treatments in our
 241 exclusion experiments for each pitaya type, and calculated the proportion of fruits that would drop to
 242 lower size bands for each pitaya type k in the absence of bat pollinators (Table 1). We assumed the
 243 most conservative size band changes by minimising the number of size bands dropped by fruits i.e.
 244 where a large fruit could have become either a medium fruit or a small fruit (as there were more
 245 fruits in both smaller band without bat pollinators), we chose a drop of one band rather than two.

246

247 Table 1. Percentage of fruits that moved between each size band in the absence of bat pollination for
 248 each cultivar and wild cacti, based on weights of fruits collected from exclusion experiments under
 249 nocturnal and diurnal pollination treatments.

250

	Large: no change	Large → medium	Large → small	Medium: no change	Medium → small	Small: no change
Blanco	0	9	24	2	9	56
Mamey	33	0	47	0	0	20
Tenamaxtle	6	25	62	0	7	0
Wild	0	0	16	0	21	63

251

252 The drop in size bands implies that the total value of pitaya fruits V would be lower in the absence of
 253 bat pollination because the fruits would be smaller, and producers would obtain lower prices per
 254 fruit. We weighted prices received by each producer at the beginning, middle and end of the season
 255 by the approximate volume sold in each time-band. Dependency values were therefore specific to
 256 each producer and depended on the weighted prices that each producer could negotiate at each size
 257 band: for example, a producer that received the same price for large and medium fruits would have a

258 lower dependency value attributable to the decrease in fruit size in the absence of bat pollination than
 259 a producer that sold large fruits for a higher price than medium fruits. We calculated D_{qkw} by
 260 multiplying the percentage of fruits that would change size in the absence of bat pollination for each
 261 price-size category for each pitaya type S_{qk} by the difference in prices received by each producer.
 262 We then summed the differences across the price-size categories (see Supporting Information S2 for
 263 an example of this calculation):

$$264 \quad D_{qkw} = \sum^Q (S_{qk} \cdot \frac{P_{wq0}}{P_{wqb}}) \quad (\text{Eq. 5})$$

265 where $\frac{P_{wq0}}{P_{wqb}}$ is the fractional change in price received for each pitaya type for each producer, with
 266 P_{wq0} indicating the price received per fruit in the absence of bat pollination (for size band q_0), and
 267 P_{wqb} indicating the price received per fruit with bat pollination (for size band q_b). S_k is based on the
 268 information in Table 1, and is the percentage difference in the number of fruits moving between each
 269 size band q per variety k in the absence of bat pollination.

270 To assess the contribution of bat pollination to employment in the pitaya sector, we estimated total
 271 extra jobs J_b generated by bat pollination by multiplying the total number of employees E of each
 272 producer by the proportion of revenue attributable to bats $\frac{V_{bw}}{V_w}$. For example, we assumed that a
 273 decreased revenue of 35% would result in a workforce decrease of 35%. Thus:

$$274 \quad J_b = \sum^W (\frac{V_{bw}}{V_w} \cdot E_w) \quad (\text{Eq. 6})$$

275 where J_b is total extra jobs generated by bat pollination, and E_w is the number of employees of each
 276 producer.

277 To estimate the total gross value of bat pollination services to the pitaya sector in Techaluta de
 278 Montenegro, we identified all likely *Stenocereus queretaroensis* plantations within the municipal
 279 boundaries of Techaluta de Montenegro, using satellite imagery. We marked the plantations as

polygons and exported them to ArcGIS to calculate the area covered in hectares (Google Earth, 2019).

3.4 Value chain analysis

We used the data collected through interviews with different actors to understand the production, processing, marketing, and consumption stages of the pitaya value chain (Appendix B). To better understand the distribution of economic benefit provided by bat pollination services, we assessed the proportion of income attributable to bats, profit, and hourly earnings across actors.

We first estimated the proportion of income attributable to bats for each actor. For all actors that produced fruits themselves we extracted values for the percentage of income attributable to bats from changes in both yield D_{yk} and quality D_{qkw} , from our individual level data collected through interview questions on production and marketing (section 3.3). A mixed model from the exclusion experiment detailed in section 3.1 provided an average estimate of D_y for individuals that did not produce fruits themselves. For actors whose income depended on the quantity but not quality of pitaya fruits, we assumed the proportion of their income attributable to bats was equivalent to D_y . This was assumed for waged workers (work availability depends on fruit volume, but we had no data on the specific volumes of fruits of each cultivar handled by their employers) and plantation owners that rented plantations to others (rent is calculated by number of fruits). For actors whose income depended on both quality and quantity of fruits (e.g. intermediaries and all types of vendors), but that did not produce fruits themselves, we calculated profit margins for small, medium and large fruits during peak production (as the bulk of fruits are sold during this time) by subtracting costs of buying fruits from prices received when selling fruits. We then inferred the overall volume of fruits of each cultivar in the market from the overall proportion of each cultivar under production across our sampled producers; and used data collected in section 3.3 on the proportion of fruits of each cultivar in each of the small, medium and large size categories (Table 1) to estimate the overall proportions of fruits in the market of each size category with and without bat pollination. We multiplied the

305 proportion of fruits in each size category by the profit margin calculated for each actor, in scenarios
306 of selling 100 fruits in both bat pollinator presence and absence, and took the difference between the
307 two as the per cent increase in profit attributable to increased fruit quality with bat pollination. The
308 proportion of income attributable to bats for product makers was assumed to be equivalent to D_y , as
309 the prices of products did not vary according to the size of fruit used to make them.

310 We then calculated profit earned by each individual interviewed by subtracting direct costs incurred
311 by pitaya-related activities (costs of renting pitaya plantations, agricultural inputs, salaries and
312 compensations for employees or family members, marketing, transport, tools and equipment, loans,
313 buying pitayas) from gross pitaya income (the sum of any income generated by selling pitaya fruits
314 V, pitaya flowers, and/or pitaya products, as well as income generated by renting out pitaya
315 plantations). Fixed costs e.g. of establishing pitaya plantations were not included in our calculations
316 of costs and profits. For waged workers, costs (e.g. commuting, food, tools and equipment,
317 maintenance) were subtracted from the hours worked in the season multiplied by the hourly wage
318 received.

319 Finally, we calculated the profit attributable to bats by multiplying profit by the proportion of income
320 estimated to be attributable to bat pollination services. Estimates of profit attributable to bats
321 involved an assumption of constant variable costs per fruit (though we acknowledge that marketing
322 and transport costs will probably not decrease linearly with decreased production).

323 To incorporate the number of dependents reliant on pitaya-generated income across actor groups, we
324 calculated the per capita monthly income of actors by dividing monthly income by the number of
325 people living in each household. To elucidate the trade-off between profits, working hours and
326 reliance on unpaid labour by family members, we calculated the hourly wages of each actor group by
327 dividing total profit by total hours worked unsalaried on pitaya-related activities by the respondent or
328 family members; except for waged workers where fixed hourly wages received are reported.

329 To understand the importance of pitaya-generated income, we collected data on whether respondents
330 used it for direct household provisioning or were able to save or invest it for long-term benefit, for
331 example by spending it on school fees. We also asked about other income generating activities
332 throughout the year, and the proportion of yearly income generated by the pitaya. We evaluated
333 constraints to access profitable roles in the pitaya chain by combining qualitative interview data with
334 quantitative costs data.

335 We tested for differences between groups in profit, hourly wage and per capita monthly income with
336 a Kruskal-Wallis test followed by non-parametric (Dunn) pairwise tests (using R packages ‘FSA’
337 and ‘rcompanion’; Mangiafico, 2019; Ogle et al. 2019). We also calculated the Gini coefficient of
338 inequality between groups in profit and hourly wage (using R package ‘DescTools’; Signorell,
339 2019). Statistical analysis was done in R v. 3.5.3., using R packages ‘dplyr’, ‘tidyr’ and ‘Rmisc’
340 (Hope, 2019; R Core Team, 2019; Wickham and Henry, 2019; Wickham et al. 2019).

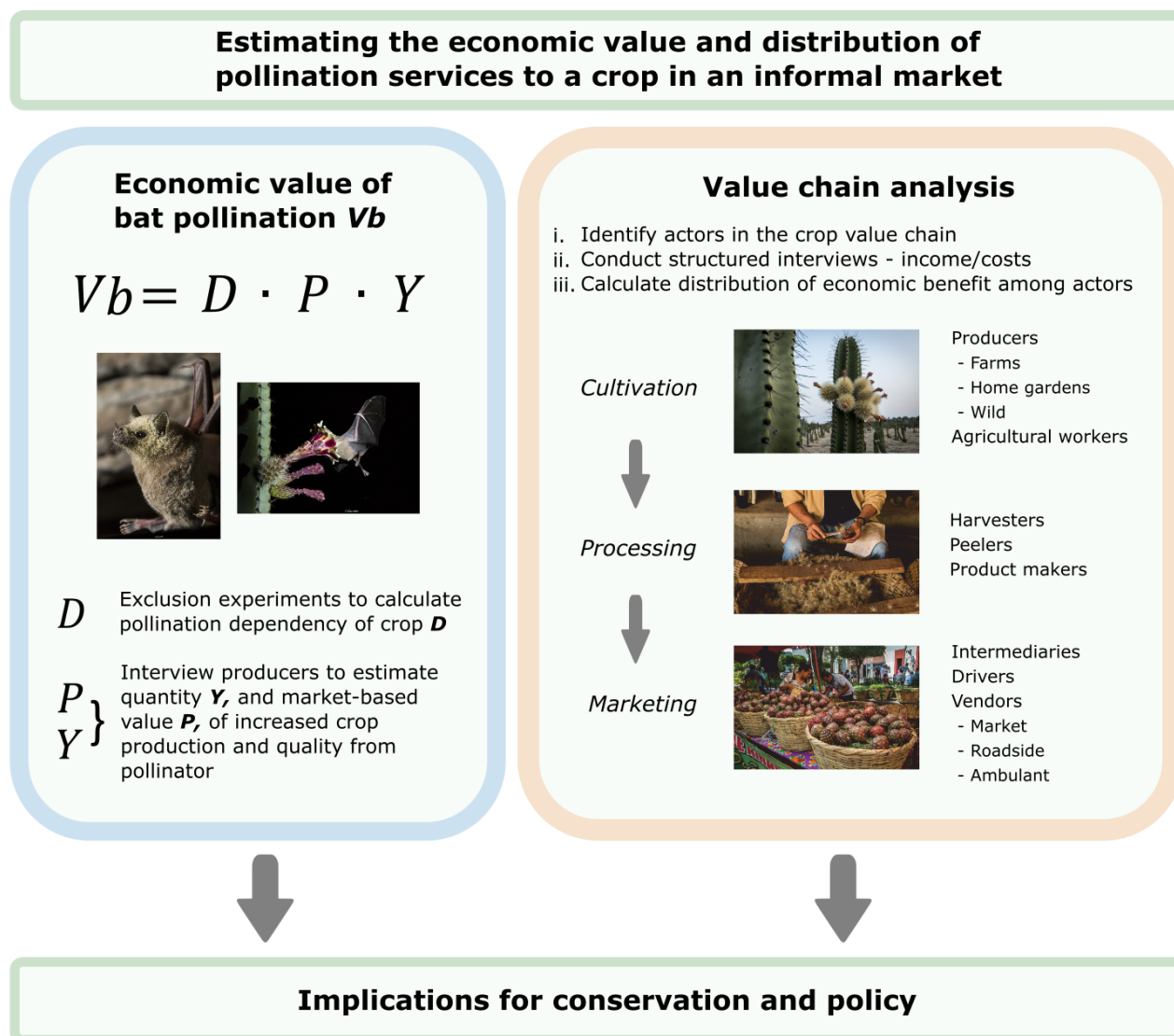


Figure 1. Synthesis figure of the valuation approach.

4. Results

4.1 Economic value of bat pollination service to pitaya production in Techaluta de Montenegro

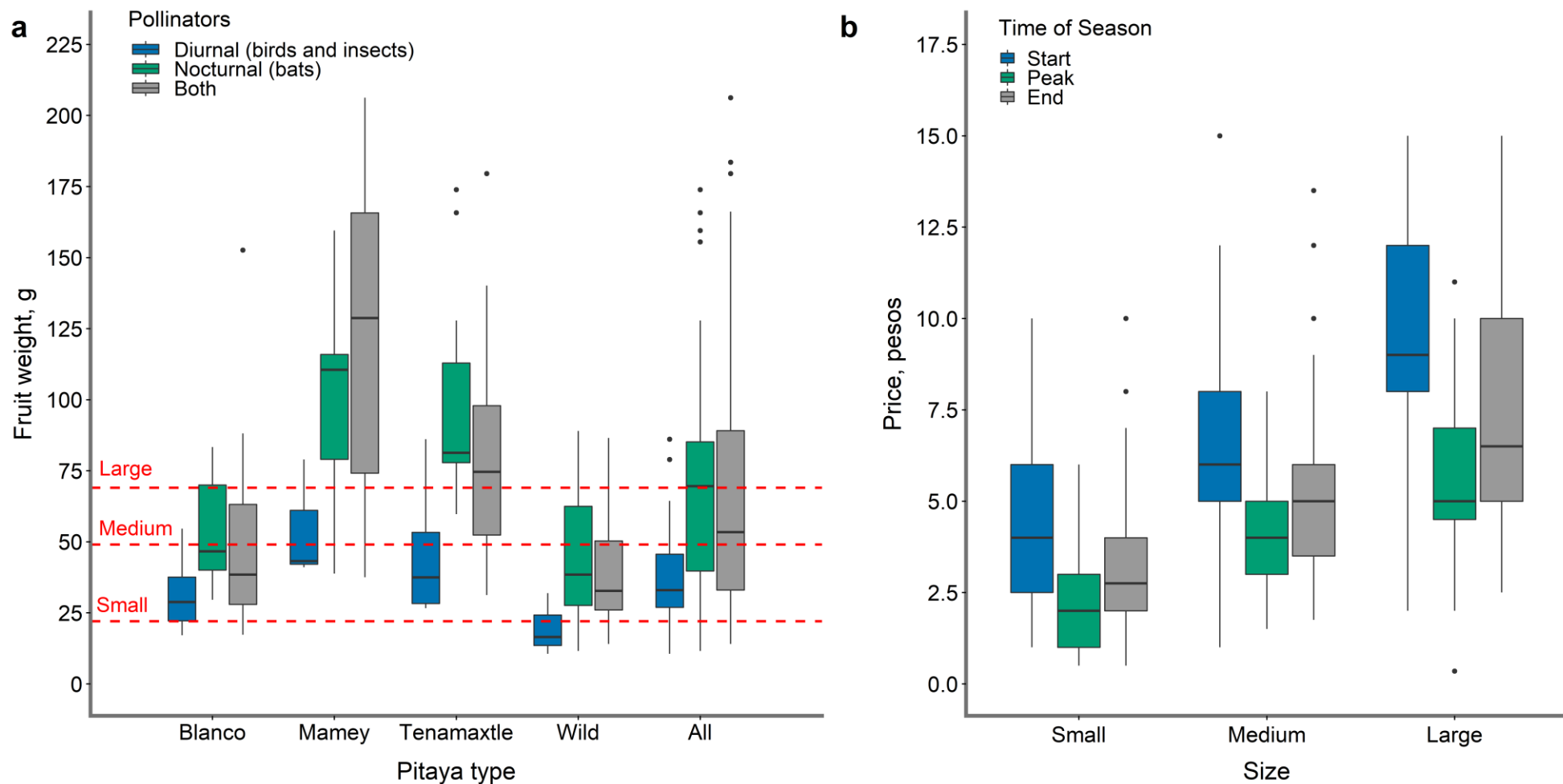
Pollination by bats resulted in a greater probability of fruit set compared to other taxa in our exclusion experiment, increasing overall probable yield by 35% when averaged across cultivars and wild cacti (GLMM: $\chi^2 = 286.7$, $P < 0.0001$; Tremlett et al. 2019). However, the dependence on bats for fruit set varied between cultivars. Yield increased by 27% for Mamey (GLMM: $p < 0.001$) and 35% for wild individuals (GLMM: $p = 0.002$), but there was no effect of bat pollination on yield for Tenamaxtle (GLMM: $p = 0.65$) and Blanco (GLMM: $p = 0.60$) individuals. Crop dependency on bat pollination D_{yk} was therefore 0.27 for Mamey, 0.35 for wild, and zero for Blanco and Tenamaxtle individuals; and 0.35 when averaged across cultivars D_y . Neither the closed pollination nor pollination by nocturnal insects treatments resulted in fruit set.

Fruit weight decreased by 46% in the absence of bat pollination across all exclusion experiment fruits (excluding the two treatments that did not set fruit and could therefore not be included in analyses of crop quality). The dependence of the pitaya crop on bat pollinators for quality D_{qkw} varied with producer, as it depended on the price charged for fruits of different sizes, but the impact on price was highest for Mamey and Tenamaxtle cultivars, which dropped one or two price bands when bats were excluded (Table 1; Fig. 2a).

Of the 61 pitaya producers interviewed, 39 owned pitaya plantations, 40 rented pitaya plantations and 20 owned home gardens (some respondents produced fruit under more than one system). The total area under production for each producer ranged in size from 0.03 to 12 ha (mean = 2.58 ha), and fruit production Y_w ha⁻¹ ranged from 4,200 fruits ha⁻¹ per season to 633,300 (Table 2). The most commonly managed cultivars of *Stenocereus queretaroensis* were Mamey (63% of total cacti under production across producers interviewed), Tenamaxtle (7%) and Blanco (7%); as well as wild cacti (10%).

381 Bigger fruits command higher prices than smaller fruits (Fig. 2b). Vendors separate fruits into large,
382 medium and small categories, with some adding categories at the extreme (tiny, jumbo). There is no
383 minimum size for a pitaya fruit to enter the market. No other fruit characteristics (e.g. cultivar)
384 affected fruit price at markets we visited. Weights of small fruits measured at markets in 2018 ranged
385 between 21.7 and 42.1g (n = 10), medium fruits between 56.3 and 69.5g (n = 10), and large fruits
386 between 68.1 and 90.6g (n = 10). Fruit prices are highest at the beginning of the season (late May),
387 when there is less fruit available and consumer demand is greatest (Fig. 2b). Prices are lowest during
388 peak production (June).

389



390

391 Figure 2. a) changes in fruit weight observed in exclusion experiments in 2016 between diurnal and nocturnal pollinators.

392 Red dashed lines indicate lower weight boundaries of different price classes observed in markets in 2018 (small, medium and large); b) final prices

393 (charged to the consumer) of fruits of different price classes (small, medium and large) at different times of the season in 2017: start = late May; peak =

394 June; end = early July.

395 Increased fruit yield resulting from bat pollination across the 61 producers interviewed had a mean
396 total value (before costs) V_{ybw} of Mex\$39,900 per producer (range: Mex\$600 to 320,300 / US\$32 to
397 16,700; Table 2). The mean value of increased fruit size resulting from bat pollination V_{qbw} was
398 Mex\$39,500 (range: Mex\$0 to 298,400 / US\$0 to 12,500; Table 2) per producer interviewed. Thus,
399 by increasing fruit yield and size, bat pollination has a mean total market value V_{bw} of Mex\$79,300
400 per producer, or Mex\$48,400 (US\$2,530) per ha (range: Mex\$1700 to 246,400 / US\$87 to 12,900;
401 Table 2).

402 The percentage of gross crop value attributable to bat pollination ranged from 5% to 58% across
403 interviewed producers, with bats contributing a mean 39% (± 12 SD) of gross revenues from fruit
404 sales per producer (Table 2), or 42% of total gross income summed across producers. Producers with
405 a higher proportion of Mamey and wild cacti were more dependent on bats for total income, because
406 fruit yield increased with bat pollination relative to diurnal pollination for Mamey and wild cacti, but
407 not Tenamaxtle and Blanco. Additionally, producers that received higher prices for large Mamey and
408 Tenamaxtle fruits than medium or small fruits benefited more from bat pollination, as fruits dropped
409 one or two size-price bands in the absence of bat pollination.

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Table 2. Characteristics of pitaya production and value of bat pollination services across the 61 interviewed producers.

	Size of plantation, ha	Y_w ha ⁻¹ , # fruits	V_w , Mex\$	Price of a small fruit ¹ , Mex\$	Price of a medium fruit ¹ , Mex\$	Price of a large fruit ¹ , Mex\$
Mean ± SD	2.58 ± 2.83	51,547 ± 90,914	187,895 ± 254,146	2.0 ± 1.0	3.5 ± 1.2	5.0 ± 2.0
Range	0.03 – 12.00	4233 – 633,333	4,500 – 1,350,000	0.5 – 5.2	2.0 – 7.3	1.9 – 10.5
	Y_{bw} , # fruits	V_{ybw} , Mex\$	V_{qbw} , Mex\$	V_{bw} , Mex\$	V_{bw} ha ⁻¹ , Mex\$	% V attributable to bats
Mean ± SD	12,447 ± 18,743	39,861 ± 59,915	39,460 ± 58,356	79,321 ± 116,023	48,405 ± 53,112	39 ± 12
Range	335 – 94,920	610 – 320,355	0 – 298,399	610 – 618,754	1660 – 246,393	5 - 58

420

421 ¹ Prices weighted by approximate volume sold at different times during the season (different prices
422 are received by farmers at the beginning, middle and end of the season; see Fig. 2b).

423 Y_w ha⁻¹: total number of fruits produced each year (yield) per hectare. V_w : gross revenues from fruit
424 sales. Y_{bw} : total yield attributable to increase in fruit set with bat pollination relative to other taxa.
425 V_{ybw} : total value of yield increase with bat pollination per producer. V_{qbw} : total value of size increase
426 with bat pollination per producer. V_{bw} : total value of yield and size increase with bat pollination. V_{bw}
427 ha⁻¹: value of bat pollination per hectare of pitaya plantation. % V : percentage of gross revenues from
428 fruit sales attributable to increases in yield and size of pitayas due to bat pollination.

429

430 We estimate that income attributable to bats for the 61 producers interviewed generated
431 approximately 129 extra jobs further down the production chain (e.g. peelers, harvesters), though we
432 acknowledge that job creation is not linearly associated with income. The number of paid workers
433 employed by producers ranged from 0 to 33.

434 We classified 190 ha of pitaya plantations within the municipal boundaries of Techaluta de
435 Montenegro from satellite images. This is likely to be an underestimation of the likely total area, as
436 we could not distinguish spatially dispersed wild cacti and cacti grown in home gardens. Thus, we
437 conservatively estimate the total gross value of bat pollination services to the pitaya in Techaluta de
438 Montenegro to be approximately Mex\$9,200,000, ranging between Mex\$315,000 and
439 Mex\$46,800,000 (US\$480,000: between US\$16,500 and US\$2,450,000).

440

441 **4.2 Value chain analysis**

442 **4.2.1 Income and employment**

443 Jobs generated by pitaya production are a chief source of employment in an area lacking many other
444 opportunities and provide an important source of income and a strategy to diversify livelihoods (see
445 Table S3 for a description of all actors and their roles). The pitaya was cited as the principal source
446 of income by 49% of respondents, though only one household was completely reliant on the pitaya;
447 all other households had multiple income streams. Participation in the pitaya chain is therefore a
448 ‘gap-filling activity’ for most people: one that provides a seasonal income during the period of low
449 agricultural activity, thus increasing its relative importance and compatibility with other livelihood
450 activities (Marshall et al. 2006). The actor groups most heavily dependent on pitaya-generated
451 income over the year, and therefore bat pollination services, were intermediaries and market vendors
452 (an estimated 55% and 46% of yearly income respectively), with waged workers reporting between
453 15% (drivers) and 26% (harvesters) of yearly income coming from work with pitayas (Table 3).

454 However, the pitaya chain is characterised by informal, verbal contracts: just 33% of fruit sellers and
455 45% of waged workers had a contract arranged prior to the fruiting season, and all were verbal.
456 Participation in the pitaya value chain thus precludes permanent, formal work with benefits such as
457 health insurance and pensions that only accrue to workers in continuous employment, creating a lack

458 of social security for most actors. Despite this, the lack of technical entry requirements, instant
459 generation of cash at low times of the year, and higher wages relative to other low-skilled jobs,
460 makes the pitaya sector an attractive employment option for resource-poor people. Working with
461 pitayas offers a higher daily rate during the pitaya season than many other concurrent available job
462 opportunities, such as agricultural day labouring (Mex\$200 per day) or jobs tending plants in large
463 greenhouses that grow berries for the export market (Mex\$120 per day).

464 The discrepancy between the highest and lowest mean hourly wages of actors in the value chain
465 (Gini coefficient = 0.67) indicates inequality in the distribution of both economic benefits and labour
466 costs between actors. The low agricultural requirements of the cacti result in a low labour cost for
467 landowners, particularly those that rent plantations to others for the production season. Actors that
468 had multiple functions in the value chain, such as market vendors that produced and sold fruit
469 themselves, commonly worked very long hours of up to 22 hours a day. The mean hourly wage of
470 plantation owners who rented plantations to others was 22.6 times higher than that of peelers and 5.4
471 times higher than that of market vendors (Mex\$543, Mex\$24 and Mex\$101 per hour respectively;
472 Table 3).

473

474 Table 3. Income indicators for different actor groups.

475

¹ Actor	Peelers*	Agricultural workers*	Ambulant sellers	Drivers*	Product makers	Harvesters*	Home garden owners	Roadside vendors	Plantation owners -do not rent out	Market vendors	Producers – sell fruit with spines	Producers – sell peeled fruit	Intermediaries	Plantation owners – rent out	Kruskal – Wallis test 3
N	12	6	5	4	9	11	20	31	30	19	8	4	4	9	
Income indicators based on calculations in section 3.4:															
Wage/Profit*, Mex\$ ± SE	17,201 ^{ab} ± 3,856	7,500 ^a ± 2,869	45,156 ^{bcd} ± 6,214	10,369 ^{ab} ± 5,331	27,277 ^{abc} ± 7,048	12,126 ^a ± 1,413	49,751 ^{bc} ± 11,717	57,531 ^c ± 13,818	78,083 ^{cd} ± 18,504	125,590 ^d ± 24,979	17,505 ^{ab} ± 7,350	127,099 ^{bcd} ± 90,386	96,419 ^{cd} ± 47,984	102,409 ^{cd} ± 51,970	$\chi^2 = 64.2$, df = 13, p < 0.0001
Hourly wage Mex\$ ± SE	24 ^b ± 2	25 ^{ab} ± 0	31 ^{ab} ± 8	32 ^{abc} ± 9	35 ^{ab} ± 8	39 ^{abc} ± 7	47 ^{ab} ± 8	47 ^b ± 12	90 ^{ab} ± 25	101 ^{abc} ± 24	125 ^{abc} ± 55	165 ^{abc} ± 135	183 ^{ac} ± 61	543 ^c ± 234	$\chi^2 = 34.2$, df = 13, p = 0.001
Income indicators based on answers to interview questions:															
Per capita monthly income Mex\$ ± SE	1003 ± 198	1327 ± 217	1410 ± 370	1234 ± 115	2003 ± 653	1436 ± 228	1664 ± 382	1459 ± 220	2150 ± 409	2921 ± 871	1881 ± 189	1879 ± 221	2917 ± 896	3767 ± 1444	$\chi^2 = 11.0$, df = 13, p = 0.61
² Per cent yearly income from pitaya	23	23	23	15	33	26	35	36	45	46	32	35	55	37	

476

477 ¹The majority of respondents belonged to multiple actor groups, so individual data may be used for several groups (e.g. plantation owners that are also market vendors). Product
478 makers here are those that did not also sell fruits (i.e. were solely product makers). Producers here are those that produce fruit but do not sell it directly to the consumer, but instead to
479 another vendor or intermediary, either peeled or with spines.

480

481 *Waged workers.

482 ² Per cent of yearly income from the pitaya calculated from the average category rank that actors reported during interviews in answer to the question “What percentage of your
483 average annual income comes from the pitaya?” (1= 0-20%, 2= 20-40%, 3= 40-60%, 4= 60-80% and 5= 80-100%). The mid-point of each category range was used.

484 ³ Unlike letter superscripts indicate significant differences between mean incomes based on non-parametric (Dunn) pairwise tests at $p < 0.05$, using the Benjamini and Hochberg
485 correction (using R packages ‘FSA’ and ‘rcompanion’ Mangiafico, 2019; Ogle et al. 2019).
486

487

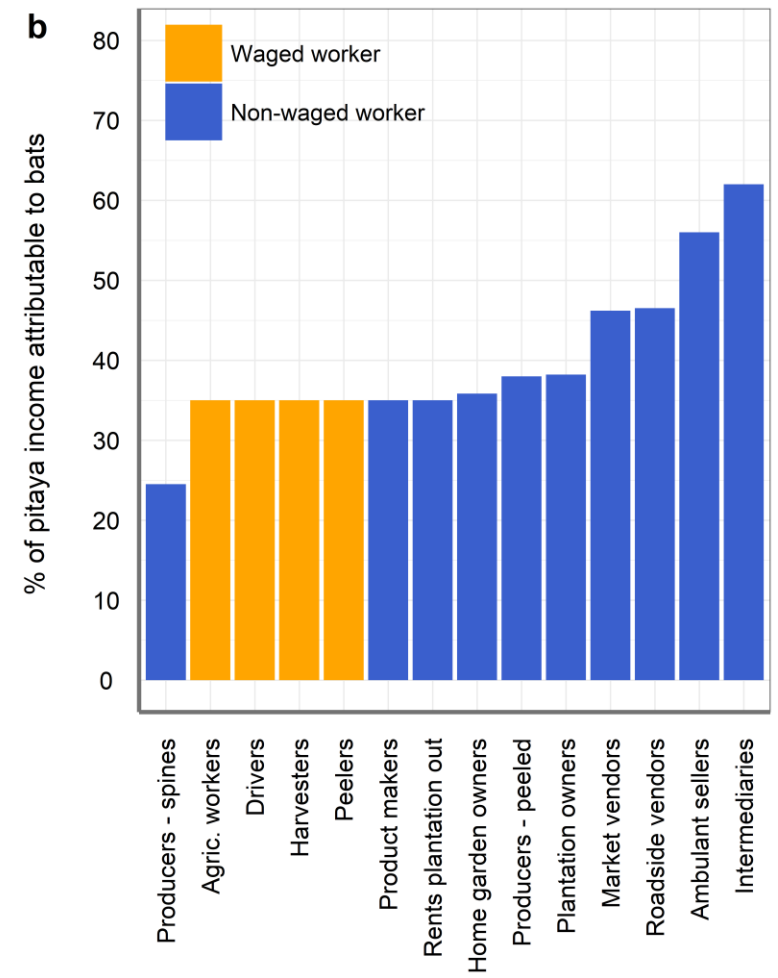
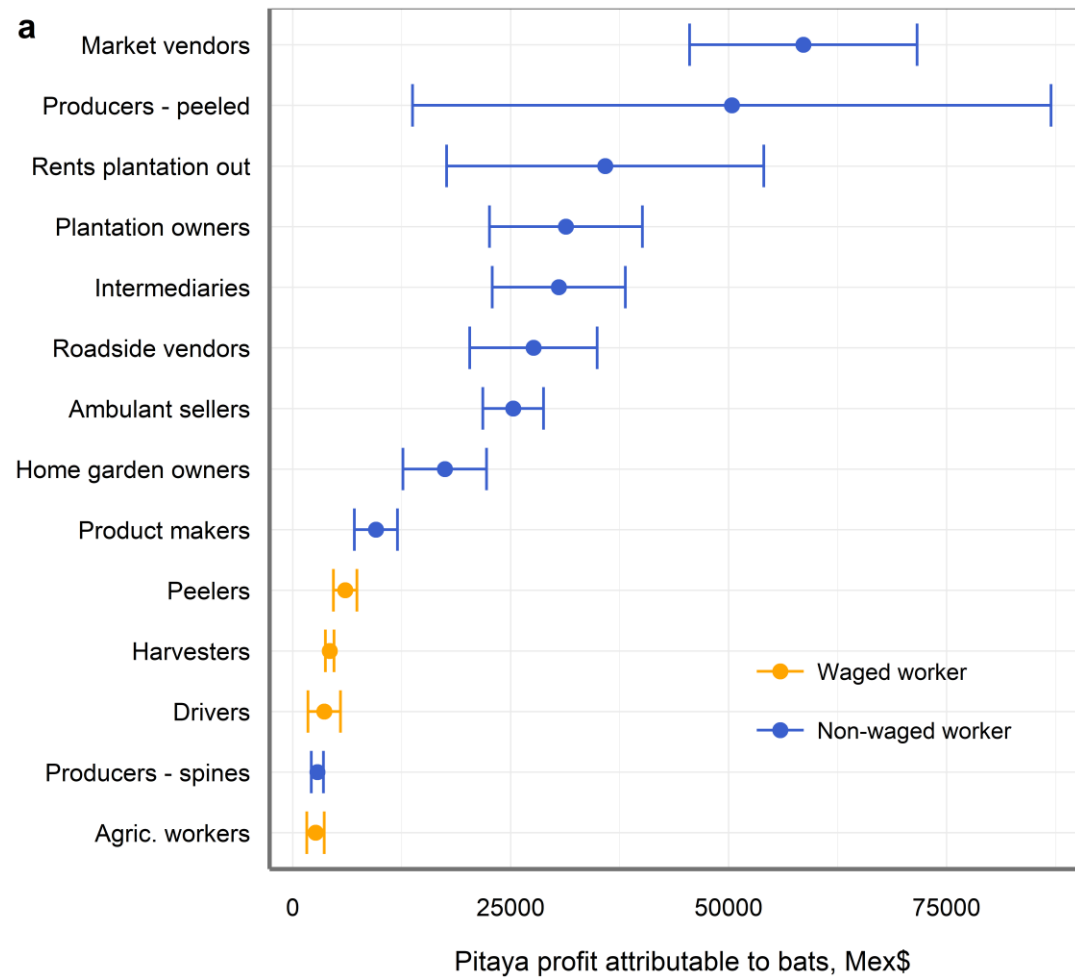


Figure 3. a) The profit in Mex\$ attributable to bats ($\pm$ SE) across actor groups, calculated by multiplying profit by the proportion of income attributable to bats for each actor (for waged workers, 'profit' is wage received multiplied by hours worked, minus costs), and b) the mean percentage of pitaya-generated income estimated to be attributable to bats for each actor group.

4.2.2 Costs

Wages and benefits are a major cost for all the different actors except intermediaries (Table S4). Transport costs (predominantly petrol) and rent are important costs for marketing actors. The costs incurred by intermediaries and market vendors are the highest, while plantation owners have among the lowest costs, thanks to the low agricultural inputs required (Table S4). A mean of Mex\$1,260 per ha per year (US\$66) was spent on compost, fertilisers, herbicides and pesticides combined. However, there is a high initial fixed cost of establishing pitaya plantations, representing a significant barrier to entry for other actors. Establishment costs are between approximately Mex\$9,460 – 72,300 per ha (US\$494 – 3,780 per ha), excluding the price of buying land, consisting of the costs of labour and buying cactus branches to plant. Furthermore, there is then a lag time before fruit production of up to 10 years. Access to formal credit is low: six percent of waged workers had access to credit and thirteen percent of non-waged workers. There was no significant difference between actor groups in per capita monthly income (Table 3), though those that earned the highest (plantation owners that rent their plantations out to other people, Mex\$3,770 ± 1444 SE) had a per capita monthly income of nearly four times those who earned the lowest (peelers, Mex\$1,000 ± 198 SE), indicating that access to land may be captured disproportionately by an already economically privileged group.

The majority of the income (84%) associated with pitayas accrues to the local community and is retained as cash income, supporting household activities (Table S5). Cash income generated from the pitaya was allocated to: household food (71% of respondents), rent and bills (54%), investment back into pitaya or other businesses (40%), savings (37%), household goods (36%), childrens' education (30%) and other uses including medical bills and paying debts (19%). Little pitaya-generated income is passed onto the government (7%) as few taxes are paid; most government revenue results from actors buying petrol from the state-owned distributor (Table S5). External agents, for example suppliers of packaging or agricultural inputs, accounted for the remaining 9% of pitaya-generated income (Table S5).

4.2.3 Profits

The distribution of profits between actors was unequal (Gini coefficient = 0.60). The highest profits (income minus direct costs) were gained by market vendors who both produced fruits and sold them directly to the consumer, achieving the highest final fruit prices (Table 3; Fig. S1). However, intermediaries, producers and plantation owners all earned a higher hourly wage (Table 3) indicating the high labour cost (long working hours) of market vendors. Additionally, many market areas have become saturated, with vendors citing too much competition from other sellers as a primary obstacle to making profit. The barriers to accessing the most profitable marketing situations are access to a vehicle and obtaining selling permits. Plantation owners that rented plantations to others achieved both the highest hourly wage and the second highest profit. As the plantations require little maintenance or input of resources, profit margins are good both for owners renting pitaya plantations out for the season for a fixed sum of money, and for those that harvest and sell the fruit themselves.

Producers that sold peeled fruits to other vendors could earn very high profits but there was substantial variation across respondents (Table 3). Profits earned by this group in our study are biased by one producer that had a very high production and took the fruits to Guadalajara to sell direct to market vendors; producers that sold to vendors or intermediaries in Techaluta earned much lower profits. The localised nature of the pitaya market results in a good level of market information throughout the chain and enables direct market access by most actors. This increases the power of producers to earn a fair price and results in intermediaries being uncommon, who frequently earn excessive profits in value chain assessments (Marshall et al. 2006). Nonetheless, the few intermediaries active in the pitaya chain earn a high profit due to the large number of fruits traded, despite earning the lowest profit margin on fruits (Table 4) and having the highest costs (Table S4).

A substantial part of pitaya-generated profit for all actor groups could be attributable to the impacts of bat pollination on crop yield and quality (Fig. 3a and b). Actors whose profits depended on the

quality of fruits as well as quantity were more dependent on bat pollination services than actors who depended on quantity only, as profit margins per fruit decreased with fruit size (Table 4), and fruits were smaller in the absence of bat pollination. Intermediaries, and ambulant, roadside and market vendors had the largest mean percentage of profits attributable to bat pollination (62, 56, 47 and 46% of profits respectively; Fig. 3b). Actors with the highest value of profit attributable to bat pollination services however, were those that earned the most from working with pitayas: market vendors, producers and plantation owners (Fig. 3a; Table 3).

551

Table 4. Profit margin (Mex\$) per fruit of each size category during peak production ($\pm$ SD) for actors buying fruit to sell rather than producing their own (cost of buying fruit subtracted from sale price received for fruit).

555

	Small Mex\$	Medium Mex\$	Large Mex\$
Intermediaries	0.3 $\pm$ 0.3	0.6 $\pm$ 0.4	1.1 $\pm$ 0.8
Ambulant vendors	1.5 $\pm$ 0.4	2.3 $\pm$ 1.1	3.6 $\pm$ 1.2
Roadside vendors	1.3 $\pm$ 2.5	3.3 $\pm$ 1.8	4.3 $\pm$ 1.1
Market vendors	2.5 $\pm$ 0.0	4.1 $\pm$ 0.5	6.8 $\pm$ 2.5

556

557

558 **5. Discussion**

559 Our study used an interdisciplinary approach to examine both the value of the direct impacts of bat
560 pollination on crop yield and quality, as well as a disaggregated analysis of the distribution of the
561 economic benefits among actors. We found the value of bat pollination services to be worth
562 approximately US\$480,000 in the municipality of Techaluta de Montenegro alone, highlighting the
563 great importance of bat pollinators for the welfare of the rural production region, and the severe
564 economic consequences should bat pollinator populations decline.

565 *Leptonycteris yerbabuenae* populations suffered severe declines in the 1980s, resulting from
566 persecution and disturbance at roosts and loss of foraging habitats (Medellín, 2016). A conservation
567 recovery programme has successfully used environmental education and roost protection schemes to
568 increase population sizes, resulting in delisting of the species by both the Mexican and US
569 governments (Trejo-Salazar et al. 2016; US Fish and Wildlife Service, 2018); though the species
570 remains classified Near Threatened by the IUCN Red List (Medellín, 2016). However, it is vital that
571 public awareness of the ecosystem services provided by bats continues, especially the contribution of
572 bats to food security. This is particularly pertinent in the light of the recent Covid-19 pandemic that
573 has widely negatively associated bats with the virus, driving new threats to bat populations (Fenton
574 et al. 2020; Zhao, 2020). Our own recent engagement with inhabitants of the pitaya production area
575 indicates growing concern about subsequent negative public perceptions of bat-pollinated fruits.

576 Economic valuations are one way of raising awareness of the unseen benefits of bats, with local
577 context-specific research providing useful and relevant information to decision makers (Ninan &
578 Inoue, 2013). The value of pitaya-generated income is significant in an area where 49% of people
579 have an income insufficient to provide wellbeing (CONEVAL, 2010). Among individual pitaya
580 farmers within our study region, we found considerable variation in dependence on bat pollination
581 for income, highly impacted by the cultivars grown and the prices charged for fruits of different

582 sizes. However at the community scale, our research showed pitaya production to be heavily
583 dependent on bats, particularly that of the most economically important cultivar; with the spatial and
584 genetic structure of pitaya plantations likely exacerbating the reliance on bat pollinators (Tremlett et
585 al. 2019).

586 Our multi-faceted approach to estimate the value and distribution of pollination services may be
587 useful for other animal-pollinated crops; particularly those in less formal markets where a lack of
588 registered data on crop production or the value chain necessitates the collection of primary data. We
589 found that pollinator-mediated changes in fruit quality had a high impact on the estimated value of
590 pollination services, demonstrating the importance of conducting detailed field experiments to
591 generate empirical data on the dependency of both crop quality and yield on different pollinators, as
592 well as including multiple cultivars in study designs (Melathopoulos et al. 2015).

593 Additionally, we have shown that value chain analysis is a useful approach for the evaluation of the
594 social distribution of economic benefits received from ecosystem services, allowing explicit analysis
595 of inequities in income among actor groups and constraints to access roles (Gundimeda et al. 2018;
596 Zhang et al. 2018). To our knowledge there has been no such attempt to disaggregate benefits from
597 pollination services between actors for any crop (Suich et al. 2015). We found that access to the bat
598 pollination service did not have an equalising impact; with some actors receiving a disproportionate
599 share of economic benefit or labour costs, and the chain characterised by a lack of social security
600 throughout. The change of the pitaya from a communally collected resource to an individually
601 owned commodity may disadvantage poorer actors who lack the land or capital to establish
602 plantations themselves or access profitable markets, despite an overall increase in economic
603 wellbeing at the community level (Marshall et al. 2006; Kamanga et al. 2009). Laterra et al (2019)
604 found a lack of financial capital to be the most important source of inequality in access to ecosystem
605 services across Latin America; inequality then increases over time as access to land gradually

606 decreases with resource commercialisation. At the same time, the ease of entry to the pitaya chain
607 (low technical entry requirements, a local market) may lead to excessive competition between small-
608 scale producers and vendors in the production area, limiting profitability.

609

610 **5.1 Conservation and policy implications**

611 Communicating the economic benefits provided by bats helps to raise awareness among the public
612 and policy makers of the importance of bat conservation actions (Cleveland et al. 2006; Boyles et al.
613 2011; Kunz et al. 2011). Community environmental education programmes can be an important tool
614 to improve understanding of bats by generating more positive attitudes shaped by the benefits bats
615 provide, rather than the damage they may cause (for example by vampire bats, *Desmodus rotundus*,
616 which can transmit bovine paralytic rabies to livestock in Latin America) (López-del-Toro et al.
617 2009).

618 Those actors who benefit the most from bat pollination services may be best placed to contribute to
619 bat conservation practically (e.g. land owners) and economically (e.g. consumers). At a local
620 practical level, protection of bat roosts and avoidance of persecution (many bats are killed under the
621 mistaken assumption that they are vampires) will benefit bat populations, maintaining both the
622 provision of pollination services and other bat-mediated ecosystem services such as seed dispersal
623 and pest suppression (Kunz et al. 2011; Williams-Guillén et al. 2016). Additionally, to maintain the
624 provision of bat ecosystem services in pitaya plantations, it is vital that the intensification of the
625 pitaya sector does not result in increased use of pesticides and other agrochemicals. Pitaya
626 production currently is largely small-scale and organic; however, production is expanding yearly,
627 with attempts to export the fruits internationally. Pesticide exposure can have various lethal and sub-
628 lethal effects on bats, including disruption of hormones and the immune system, reproductive failure,
629 and changes to behaviour (Bayat et al. 2014). We found consumers of pitayas to have a higher

630 monthly income and level of education than any of the actors involved in the production chain (Table
631 S3), suggesting that they can afford to contribute to initiatives such as a ‘bat-friendly’ pitaya label
632 (e.g. see Trejo-Salazar et al. 2018: bat-friendly tequila). Such initiatives could add a small surcharge
633 to pitaya prices to feed into conservation efforts such as environmental education programmes or the
634 installation of protection at roost sites.

635 Until now, there have been no direct economic valuations of bat pollination services provided to
636 crops, though several studies have estimated the value of crop pest suppression by bats. Bat-mediated
637 pest control has been valued between \$0 (for coffee and cacao) and \$183 (cotton) per ha,
638 representing 0% and 12% of the total crop value respectively (Cleveland et al. 2006; Maas et al.
639 2013; Maine & Boyles, 2015; Puig-Montserrat et al. 2015; Taylor et al. 2018). The higher value of
640 bat pollination (US\$2,500 per ha) revealed by our study suggests that this may be a more effective
641 economic argument for bat conservation in some areas.

642 This research also has important policy implications for equitable development. In order to ensure
643 that benefits from bat pollination are distributed more fairly across actors, activities could be started
644 at the community, government or NGO level, such as: selling fruits or products collectively; opening
645 up new markets (with assistance to cope with any resulting extra certification or tax requirements) or
646 improving access to existing markets; supporting new actors financially to establish plantations;
647 supporting the introduction of a low-entry health insurance; and providing training and equipment to
648 increase product-making capacity.

649 **5.2 Limitations, uncertainties and knowledge gaps**

650 Fruit set and fruit quality between pollination treatments may vary between years, impacted by
651 fluctuations in climate and pollinator availability (Melathopoulos et al. 2015). Economic value will
652 also fluctuate with changes in market prices, and institutional or external environmental factors

(López-Hoffman et al. 2014). Nonetheless, our research has clearly demonstrated the economic importance of bats for the pollination of a highly valuable agricultural product. Additionally, the production value method assumes that crop prices will be unaffected by decreased supply in the case of pollinator loss, and that farmers cannot compensate for reduced pollination supply by reducing input costs or employing substitutive pollination (Winfree et al. 2011). Techaluta de Montenegro contributes 40% of registered pitaya production in Jalisco (SIAP, 2018) and therefore price increases may be seen with decreased fruit supply. However, the pitaya is already a highly priced luxury fruit, and 67% of consumers interviewed in our study said that they would buy fewer pitayas if the price increased. Input costs are already low for pitaya producers and it is unlikely they could be reduced further without loss of employment. Furthermore, bats are wild pollinators that cannot be replaced by a managed service, e.g. from rented bee hives; and the cost of hand-pollination is likely to be prohibitive (Partap and Ya, 2012), though cost estimates are not available for this crop. It was beyond the scope of this study to consider the distribution of benefits received by actors other than income. Poverty and wellbeing are complex and context dependent, now commonly described with multi-dimensional factors encompassing human and social deprivations as well as economic (Suich et al. 2015). For a better understanding of the impact of bat pollination services on wellbeing, the effect of pitaya-generated income on other objective elements of well-being (such as access to health services), and subjective elements (such as cultural importance or contribution to sense of identity) would need to be quantified.

6. Conclusion

The consequences of losing bat pollination services to pitaya production in Techaluta de Montenegro would be severe. By enhancing fruit production and fruit size, bat pollinators contributed around 40% of the total gross income of interviewed pitaya producers in the area, equivalent to US\$2,500 per ha annually. This value reflects the high level of dependence of the pitaya crop on bat pollinators

677 for both yield and quality; as well as the high prices achieved for pitayas. The reliance of local
678 employment and income on pitaya production, and thus bat pollination services, is a strong argument
679 for the conservation of bat populations in the production area. However, our value chain analysis
680 showed that barriers to access the most profitable roles should be reduced to enable a fairer
681 distribution of economic benefits among actors, which are currently disproportionately captured by
682 groups already economically or socially advantaged. Our interdisciplinary approach combining
683 exclusion experiments, plantation yield data and value chain analysis provides a novel basis for
684 valuing the benefits of services by other animal pollinators and other crops, as well as the
685 distribution of those services across actors.

686

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693 or indirectly to our work, without whom this research could not have happened.

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Supplementary Methods and Data

S1 Overview of the different stages in the pitaya value chain

Cultivation

The main actors at the cultivation stage are plantation owners and renters, and home garden owners (Table S3 describes all actors and their roles). Additionally, day labourers are employed in the management of the plantations. Agricultural inputs are low: only 24% of plantation owners interviewed used pesticides (mostly a powder applied to deter ants) or fertilisers, and 16% irrigated the cacti. Over half (54%) of plantation owners also grew crops other than pitayas. The timing of pitaya harvest in the dry season (April - June) allows producers to grow other crops during the rainy season (July - September), such as maize (22% of plantation owners) and beans (14%). 35% of plantation owners also grew fruit trees such as guamuchil, mango, avocado, orange and guava.

Processing

The main actors at the processing stage are waged workers that harvest and peel the fruits, and product makers. Pitayas are harvested manually within a day of ripening, usually in the early hours of the morning to sell the fruits the same day. Pitayas are packed with foliage (e.g. alfalfa) to keep them fresh for transportation to markets. The spines are removed from fruits by peelers before they are sold to the consumer. Most fruits are sold to the consumer fresh, but a small proportion are increasingly used to make products such as cakes, jams and punch.

Marketing

The main marketing actors are roadside and market vendors, ambulant sellers that sell on foot or from a vehicle, drivers that transport fruits, and sales assistants. The market area for pitayas is very localised, with 98% of fruits sold by interviewed vendors within the state of Jalisco, both in the production area and nearby towns and cities. 69% of all fruits sold by interviewed vendors were sold at markets in Guadalajara, the largest city in Jalisco (80km north-east of Techaluta de Montenegro). The most important of these is a traditional seasonal market dedicated to pitayas, ‘Las 9 esquinas’, which accounted for 23% of total fruits sold. 10% of total fruits are sold to consumers in Techaluta de Montenegro, from stalls by the side of the main road.

28 Most fruits are sold direct to the consumer for immediate payment. Markets are informal, and
29 contractual agreements with commercial enterprises are rare, due to difficulties with transport and
30 packaging, and lag-times in payment for goods by large companies to vendors with high overheads
31 to pay. Some fruits are exchanged for goods in shops or with travelling salesmen.

32
33

34 **S2 Example calculation of value of dependency of fruit quality on bat pollination**

35 Below is an example of how we calculated the dependency of fruit quality on bat pollination D_{qkw}
36 for one producer, ‘Producer A’:

37 Producer A receives 0.5 pesos for small fruits, 3 pesos for medium fruits and 3 pesos for large fruits.
38 He produces 10,000 fruits each year. He has 600 Blanco cacti (6%), 8400 Mamey cacti (84%), 1000
39 Tenamaxtle cacti (10%) and 0 wild cacti (0%). We use these percentages of cacti as a proxy for the
40 percentage of fruits of each pitaya type. His total income from selling fruits was Mx\$20,000, of
41 which Mx\$2,268 can be attributed to increased fruit yield resulting from bat pollination.

42 To calculate D_q for this producer for Blanco fruits, we first add up the difference in fruit price
43 resulting from changes in price/size categories in the absence of bat pollination. So, for example, if
44 large fruits remained in the large category, the producer would receive 100% of the original price
45 ((large price / large price) * 100 , i.e. here (3 pesos / 3 pesos) * 100, = 100%).

47 **Table S1. Percentage of fruits that move between each size-price category in the absence of bat**
48 **pollination for each cultivar and wild cacti.**

49

	Large: no change	Large → medium	Large → small	Medium: no change	Medium → small	Small: no change
Blanco	0	9	24	2	9	56
Mamey	33	0	47	0	0	20
Tenamaxtle	6	25	62	0	7	0
Wild	0	0	16	0	21	63

50

51 We can see from Table A1 however, that no fruits remained in the large category for Blanco fruits in
52 the absence of bat pollination, so we would multiply this price difference by zero (Table A2). 9% of
53 the fruits moved from the large category to the medium category, but there is no difference in price
54 received by the producer between large and medium fruits. We therefore multiply the proportion of
55 price change (0.00) by the proportion of fruits to make this category change (0.09; Table A2). There
56 is a decrease of 83% in price between large and small fruits, so there is a 0.83 drop in potential
57 earnings for fruits that would be large under natural pollination conditions but in the absence of bats
58 are small. The proportion of fruits to move from large to small is 0.24, so we get a total drop in value
59 of 0.1992 for these fruits (0.83 * 0.24). We do this for all the category changes and add up the totals
60 (Table A2).

62 **Table S2. Example of the calculation used to calculate D_q for producer A for Blanco fruits.**
 63

	Large: no change	Large → medium	Large → small	Medium: no change	Medium → small	Small: no change
Prop. Blanco fruits that change size categories in the absence of bat pollination (Table 1)	0	0.09	0.24	0.02	0.09	0.56
Difference in fruit price between size categories (producer specific)	100 – (3/3 * 100) = 0	100 – (3/3 * 100) = 0	100 – (0.5/3 * 100) = 0.83	100 – (3/3 * 100) = 0	100 – (0.5/3 * 100) = 0.83	100 – (0.5/0.5 * 100) = 0
Change in potential earnings due to size category change	0 * 0 = 0	0 * 0.09 = 0	0.24 * 0.83 = 0.199	0 * 0.02 = 0	0.83 * 0.09 = 0.075	0 * 0.56 = 0

64

65 Thus, the total D_q for producer A for Blanco fruits is 0.27 – i.e. the value of his Blanco fruits drops
 66 by 27% in the absence of bats. We get this total by adding up the changes in potential earnings due to
 67 size category change (last row of Table A1).

68 To calculate the value of bat pollination resulting from increased fruit quality V_{qb} , we multiply the
 69 income remaining after we have subtracted the value of bat pollination resulting from increased fruit
 70 yield from total income ($V_b - V_{yb}$), by the coefficient for the change in fruit quality D_q for Blanco
 71 fruits multiplied by the proportion of Blanco cacti under production by Producer A. So, in this
 72 example: $((\text{Mx}\$20,000 - \text{Mx}\$2,268) * (0.06*0.27)) = \text{Mx}\297 . To estimate the proportion of the
 73 income of Producer A that will be lost from decreases in size of Blanco fruits in the absence of bat
 74 pollination, we divide this by total remaining income: $\text{Mx}\$298 / \text{Mx}\$17,732 = 0.0162 * 100 =$
 75 1.62%. So for Producer A, $\text{Mx}\$297$, or 1.62% of the income remaining after we have subtracted V_{yb} ,
 76 is attributable to increases in quality (size) of Blanco fruits as a result of bat pollination.

77 We repeat this process for each of the pitaya types, and sum them to get the total value associated
 78 with increases in fruit size V_{qb} for each producer. You can see that if the producer charged more for
 79 the large fruits than for the medium fruits, then there would be a higher overall difference in the
 80 amount of money that he/she would lose from having smaller fruits in the absence of bat pollination.
 81 Likewise, for producers that have higher proportions of cacti with fruits that show a greater number
 82 of size category changes in the absence of bat pollination (i.e. Mamey and Tenamaxtle).

83

Table S3. Summary of stakeholders, their functions and characteristics

Stakeholders	N	Functions/Activities	Characteristics
Production:			
Plantation owners	39	- Own plantations of <i>Stenocereus queretaroensis</i>: bought or inherited - Some harvest fruits to sell on to consumers or other vendors - Some rent out plantations for the season, mostly for a fixed sum agreed in advance	- Majority male (61%) and middle-aged (mean age = 53). - Percentage of yearly income from pitayas = 20-40% - Pitaya principal income = 55% 71 % have access to a vehicle
Plantation renters	40	- Rent plantations for the season - Harvest fruits to sell to consumers or to other vendors	- Majority male (68%). - Mean age = 46. Median age = 46 - Percentage of yearly income from pitayas = 20-40% - Pitaya principal income = 63% 90% have access to a vehicle
Home garden owners	20	- Own small numbers of cacti in backyards - Harvest fruit for home consumption, to make into products, and to sell to vendors or to consumers	- Majority female (57%). - Mean age = 57. Median age = 56 - Percentage of yearly income from pitayas = 20-40% - Pitaya principal income = 62% 71% have access to a vehicle
Wild fruit collectors	1	- Harvest fruit from cacti on ejido (common) land - Rare commercial activity in study area: other paid work associated with pitayas preferentially chosen - Some families harvest fruits for own consumption	
Agricultural workers	6	Paid a fixed daily rate for labour on pitaya plantations such as weeding, planting cacti, building fences. Day labourer	- Mostly male (83% - check interview 112 – should be included as female TA?) - Mean age = 50. Median age = 43 - Percentage of yearly income from pitayas = 20-40% - Pitaya principal income = 67% 50% have access to a vehicle
Consultant	1	- Offers consultancy service, primarily overseeing the establishment of new pitaya plantations for absent landowners who have saved money working abroad - Respected pitaya producer, well-known for excellent technical knowledge, high quality fruits, and healthy cacti	

Processing:			
Harvesters	11	▪ Paid either a fixed hourly or daily rate. Temporary labourer ▪ Harvest fruits during the night or early morning ▪ Transport to peelers or vendors	▪ Male (100%), of all ages. ▪ Commonly either work as a harvester in addition to normal day job (e.g. in construction during the day, harvesting at night). Highest proportion compared to other actor groups manage to save at least some of their earnings (90%). ▪ Percentage of yearly income from pitayas = 20-40% ▪ Pitaya principal income = 45% ▪ 36% have access to a vehicle
Peelers	12	▪ Paid either a fixed hourly or daily rate (or rarely, by fruits peeled). Temporary labourer ▪ Peel fruits (remove the spines) and pack for transport	▪ Mostly female (92%), of all ages ▪ Paid between 20 and 30 pesos per hour: working conditions vary more than pay ▪ Do not usually work during the rest of the year, are occupied in the household ▪ Work long hours during pitaya production, both peeling fruits and continuing to be responsible for domestic duties such as childcare, cleaning and cooking. ▪ Percentage of yearly income from pitayas = 20% ▪ Pitaya principal income = 33% ▪ 33% have access to a vehicle
Managers	1	▪ Manage teams of peelers and harvesters ▪ Only employed by larger scale producers	
Product makers	25	▪ Use pitayas to make products such as cakes, jams, punch and salsas ▪ Pitayas can be sourced from own production, bought, or gifted	▪ Mostly female (76%), mean age = 46 ▪ Percentage of yearly income from pitayas = 20-40% ▪ Pitaya principal income = 40% ▪ 76% have access to a vehicle
Marketing/retailing:			
Intermediaries	4	▪ Buy fruit directly from producers and sell to other vendors ▪ Some have fixed situations (e.g. stall at wholesale market) and vendors come to them to buy fruit; others have pre-agreed arrangements and deliver the fruit to vendors ▪ Buy and sell by boxes; pay immediately and receive payment immediately	▪ Mostly male (75%) and middle-aged (mean age = 46). ▪ Percentage of yearly income from pitayas = 40-60% ▪ Pitaya principal income = 50% ▪ 100% have access to a vehicle
Roadside vendors	31	▪ Sell peeled fruits, and often other products such as flowers and cakes, direct to consumers from roadside stalls ▪ Some rely on drivers to stop cars to buy fruits; some rely on pedestrian passers-by ▪ Take immediate payment for products	▪ Majority female (61%). ▪ Mean age = 49. Median age = 50 ▪ Percentage of yearly income from pitayas = 20-40% ▪ Pitaya principal income = 55% ▪ 81% have access to a vehicle

Market vendors	19	▪ Sell peeled fruits, and often other products such as flowers and cakes, direct to consumers from stalls at a market ▪ Take immediate payment for products	▪ Pretty evenly split between men and women (53% female). ▪ Mean age = 47. Median age = 50 ▪ Percentage of yearly income from pitayas = 40-60% ▪ Pitaya principal income = 68% ▪ 89% have access to a vehicle
Ambulant vendors	5	▪ Sell peeled fruits moving from place to place either on foot or with a vehicle ▪ Take immediate payment	▪ Majority female (60%). ▪ Mean age = 40. Median age = 45 ▪ Percentage of yearly income from pitayas = 20-40% ▪ Pitaya principal income = 80% ▪ 100% have access to a vehicle
Drivers	4	▪ Transport fruits from production area to market area. Temporary labourer ▪ Often make multiple trips per day ▪ Some own their own vehicle, some drive their employer's vehicle	▪ All male ▪ Mean age 41. Median age = 39 ▪ Percentage of yearly income from pitayas = 0-20% ▪ Pitaya principal income = 25% ▪ 75% have access to a vehicle
Sales assistants	3	▪ Paid either a fixed hourly or daily rate. Temporary labourer ▪ Sell fruits from roadside or market stalls	▪ All female ▪ Mean age = 24. Median age = 25 ▪ Percentage of yearly income from pitayas = 0-20% ▪ Pitaya principal income = 67% ▪ 33% have access to a vehicle
Consumption:			
Consumers	20	▪ Consume fruits; mostly passers-by for home consumption ▪ Some restaurants buy fruits to make into e.g. drinks or desserts	▪ Mean monthly income around \$12,500; a higher income than any of the actors involved in the rest of the value chain ▪ 78% had reached a level of schooling of undergraduate degree or above ▪ Indicates that pitayas are a luxury fruit ▪ Travelled a mean time of 38 minutes to buy pitayas, almost always by car

Table S4. Mean percentage of total costs for actors in expense categories, and total costs (Mx\$ ± SD).

Actor	N	Agricultural inputs	Rent	Financial	Marketing	Tools and equipment	Buying fruits	Transport	Employee wages and benefits	Total costs Mx\$
Home garden owner	7	20.9	0	0	0	16.3	0	31.0	31.7	11,242 ± 166,73
Plantation owner	20	31.9	0	0	1.1	12.2	0	24.3	32.2	19,319 ± 36624
Intermediaries	2	0	0	0	2.9	0.7	86.5	4.2	5.9	317,775 ± 319
Ambulant sellers	5	0.4	25.9	0	0.4	4.8	18.3	23.7	26.5	84,006 ± 27,766
Roadside vendor	27	0.8	17.4	0.7	1.5	22.1	11.9	16.6	28.9	77,320 ± 95,914
Market vendor	19	0.8	19.3	0	2.0	4.8	19.5	17.8	35.9	253,529 ± 262,765

n.b. Home garden owners did not sell fruits at market or roadside, nor rent plantations. Market vendors did not sell fruits by the roadside and vice versa. Plantation owners did not also sell fruits at market or by the road, or rent plantations. Intermediaries did not also rent or own plantations. Main cost categories for each actor type are emphasised in bold.

Table S5. Distribution of economic activities between government, external and local actors. Value = the total value cited by interviewees, as either profits or costs. % = the proportion of the expense of each actor group represented by item within the actor category.

Government	Value, pesos	%	External agents	Value, pesos	%	Local community	Value, pesos	%
Export tax	2,650	0	Profits from outside vendors	357,430	27	Wages and benefits	3,411,655	27
Production tax	0	0	Selling permits	47,010	4	Plantation rents	1,922,500	15
Income tax	0	0	Agricultural inputs	48,855	4	Buying fruits	1,677,140	13
VAT	870	0	Tools and equipment	426,027	32	Profits	5,433,067	44
Property tax	30,217	3	Car insurance	128,400	10			
Certification	11,740	1	Packaging	328,249	25			
Road tolls	17,687	2						
Petrol	931,685	89						
Stall rents	47,015	5						
Total	1,041,864	7	Total	1,335,971	9	Total	12,444,362	84

Figure S1. Mean final prices for fruits received by different actors

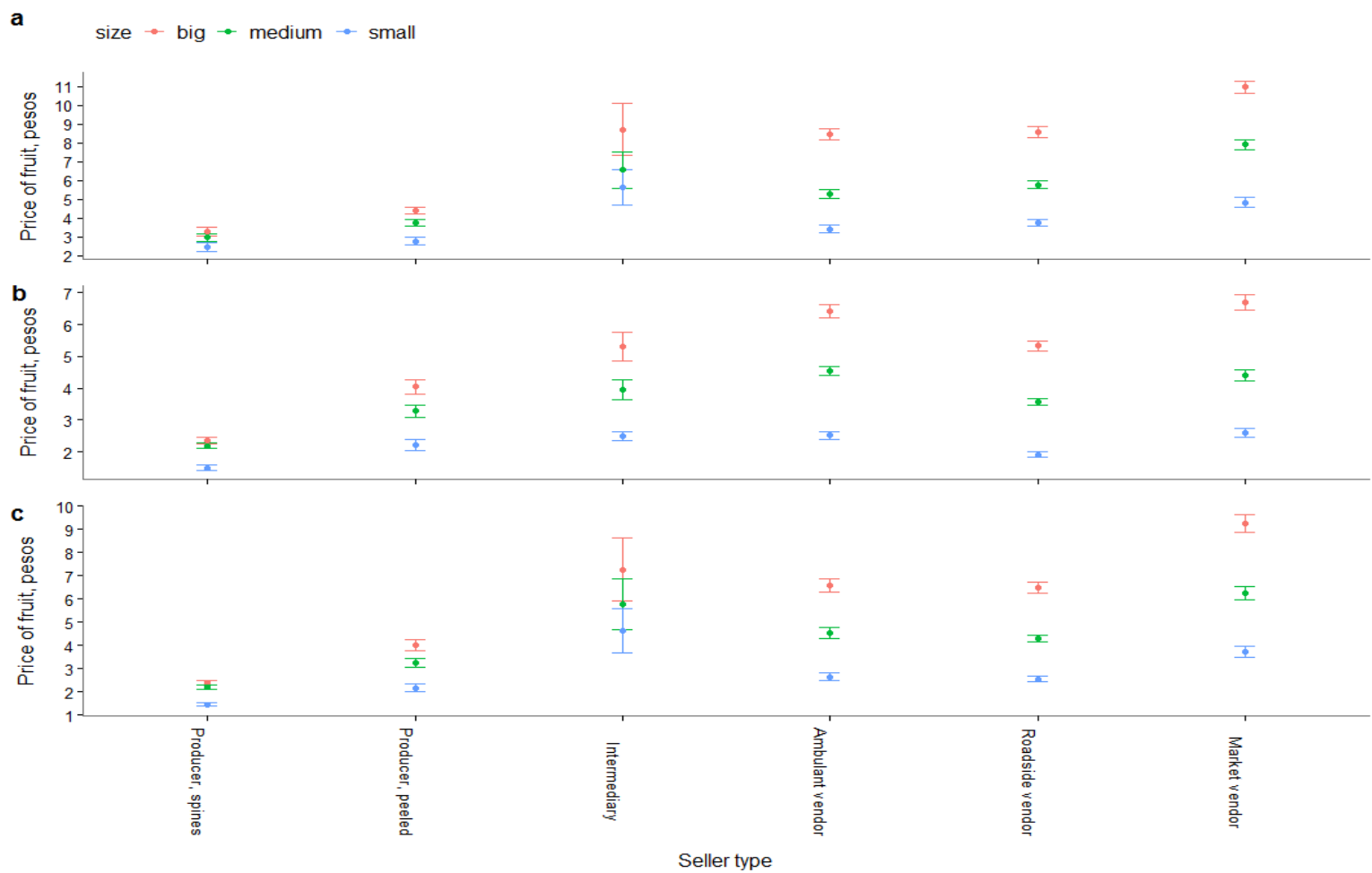


Figure S1. The mean final price of fruits ($\pm$ SE) received by different stakeholders at the **a)** start of season, **b)** peak season, **c)** end of season.

⇒ **LEER TODA LA HOJA INFORMATIVA**

⇒ **LEER TODO EL FORMATO DE CONSENTIMIENTO Y OBTENER LA FIRMA DE LOS PARTICIPANTES PARA SU CONSENTIMIENTO**



Muchas gracias por acceder a esta entrevista y ahora vamos a comenzar.

EL ENTREVISTADO ES UN (seleccionar todas las que aplican):					Entrevista número:	
	PPA	Propietario de plantación/arrendatario		CS	Cortador silvestre	Fecha de la entrevista:
	C	Cortador		HP	Hacedor de productos	Hora de inicio: Hora terminación:
	P	Pelador		I	Intermediario	Nombre del entrevistador:
	VM	Vendedor en mercado		Ch	Chofer	Consentimiento obtenido: S/N
	VC	Vendedor en carretera		VA	Vendedor asalariado	Rol primario del entrevistado:
	PS	Propietario de solar		TA	Trabajador agrícola	
Cómo se llegó a entrevistar a esta persona?						
	Recomendada por otro entrevistado				Se conoció azarosamente	Identificación previa
	Otro (especificar):					
	Encuesta revisada? Fecha:				Datos registrados? Fecha:	

Preguntar las preguntas de TODOS los roles seleccionados arriba (ej. pelador Y hacedor de productos), así como todas las secciones de TODOS LOS ENTREVISTADOS.

TODOS LOS ENTREVISTADOS: PREGUNTAS ROMPE HIELO

Vive en Techaluta de Montenegro?	☐ Si	☐ No
Si SI , por cuanto tiempo ha vivido ahí?	años	
Si NO , en dónde vive?		
Podría describir brevemente un día típico de trabajo?		

➡ Si el entrevistado es propietario de plantación o arrendatario (PPA) o propietario de un solar (PS), pasar a la sección 1.

➡ Si el entrevistado es un cortador silvestre (CS), pasar a la sección 1.2

➡ Si el entrevistado es un hacedor de productos (HP), vendedor de carretera (VC), vendedor de mercado (VM) o intermediario (I), pasar a la sección 2.



Ahora le hare unas preguntas sobre su plantación o solar y sus pitayos.

PPA, PS	PROPIETARIOS DE PLANTACIONES Y ARRENDATARIOS (PPA), PROPIETARIOS DE SOLARES (PS): 1. CARACTERÍSTICAS DE LAS PLANTACIONES DE PITAYA			
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PPA	1.1.1	Posee o renta una pitayera?				1. Posee (ir a 1.1.2)	2. Renta (ir a 1.2)
	1.1.2	Si POSEE en 1.1.1 , compró o heredo la tierra?				1. Compró	2. Heredó
	1.1.3	Si POSEE en 1.1.1 , se la renta a alguien más?				1. Si	2. No
PPA	1.2	Cuántas plantaciones posee o renta?				1.2.1 _____ posee	1.2.2 _____ renta
PPA	1.3	Cuál es el tamaño total de la(s) plantación(es) que posee/renta?				1.3.1. _____ posee	1.3.2. _____ renta
						☐ m ²	☐ hectáreas
PS	1.4	Cuál es el tamaño total de su solar?				_____ ☐ m ²	☐ hectáreas
PPA PS	1.5	Cuántos pitayos hay en total?				1.5.1 _____ posee	1.5.2 _____ renta 1.5.3 _____ solar
PPA PS	1.6	Cuál es el edad de los pitayos? Llenar el cuadro de abajo:					
	1.6.1	0-10 años	Cantidad:	1.6.4	30-40 años	Cantidad:	
	1.6.2	10-20 años	Cantidad:	1.6.5	40-50 años	Cantidad:	
	1.6.3	20-30 años	Cantidad:	1.6.6	50+ años	Cantidad:	
PPA PS	1.7	Qué porcentaje de las diferentes variedades de pitaya tiene en total?					
		1. Mamey _____ %	2. Blanco _____ %	3. Tenamastle _____ %	4. Silvestre _____ %		
		5. Morado _____ %	6. Amarillo _____ %	7. Otro (especificar: _____) _____ %			
PO PS	1.8.1	Planta otros cultivos en la misma tierra?				1. Si (ir a 1.8.2)	2. No (ir a 1.9)
	1.8.2	Si SI , cuáles?					
PO PS	1.9	Por qué prefiere cultivar pitayas en lugar de algún otro cultivo?					
PPA PS	1.10	Ofrece algún cuidado a los pitayos de sus plantaciones/solar?				1. Si (ir a 1.11)	2. No (ir a 1.12.1)
PPA PS	1.11	Si SI , qué actividades realiza? Seleccionar todas las actividades de manejo					
		1.	Rotación de suelo	4.	Aplicación de composta		
		2.	Irrigación	5.	Aplicación de pesticidas/insecticidas		
		3.	Deshierbar	6.	Adición de fertilizantes		
		7.	Otro (especificar):				
PO PS	1.12.1	Cómo propaga los pitayas?			1. No lo hago (ir a 1.13)	2. Semilla (ir a 1.12.2)	3. Brazos (ir a 1.12.2)
PO PS	1.12.2	Si propaga los pitayas , provienen las semillas/brazos de sus propias plantaciones?				1. Si	2. No
PPA PS	1.13	Tiene algún problema con plagas o enfermedades en sus pitayos?				1. Si	2. No
PPA PS	1.14	De dónde obtiene consejos o asistencia técnica para el cuidado de sus pitayos o para combatir las plagas y enfermedades?					
		1. Vendedor de productos agrícolas		2. Otros agricultores		3. Conocimiento empírico	
		4. Gobierno/servicios de apoyo gubernamentales					
		➡ Continuar con la sección 2 (producción de fruta y mercadeo)					



Ahora pasaremos a las preguntas sobre dónde y cómo colecta sus pitayas.

CS	CORTADORES SILVESTRES SOLAMENTE:				
	1.2 CARACTERÍSTICAS DE LOS SITIOS DE COLECTA				
CS	1.15	Qué tan lejos de su casa está el área de dónde colecta las pitayas silvestres?	1.15.1 minutos _____ 1.15.2 km _____		
CS	1.16	Dónde (LUGAR GEOGRÁFICO) colecta las pitayas? <i>Detallado.</i>			
CS	1.17.1	Los pitayos se encuentran en tierras privadas o comunales (ejidal)?	1. Propiedad privada (ir a 1.17.2)	2. Ejidal (ir a 1.18)	
CS	1.17.2	Si PROPIEDAD PRIVADA , usted:	1. Posee la tierra	2. Renta los derechos para cortar	3. Ninguno
CS	1.18	De aproximadamente cuántos pitayos colecta las frutas?	# pitayos		
CS	1.19.1	Colecta alguna otra planta alimenticia de esas mismas tierras?	1. Si (ir a 1.19.2)	2. No (ir a 1.20)	
CS	1.19.2	Si SI , qué plantas alimenticias?			
CS	1.20	Colecta plantas para algún otro uso, como medicinal?	1. Si	2. No	
CS	1.21	Tiene algún problema con plagas o enfermedades en los pitayos silvestres?	1. Si	2. No	
	➡ Continuar con la sección 2 (producción de fruta y mercadeo)				

PPA, PS, CS, VC, VM, I, HP	PROPIETARIOS DE PLANTACIONES O ARRENDATARIOS (PPA), PROPIETARIOS DE SOLARES (PS), CORTADORES SILVESTRES (CS), VENDEDORES DE MERCADO (VM), VENDEDORES DE CARRETERA (VC), INTERMEDIARIOS (I), HACEDORES DE PRODUCTOS (HP)
	2. PRODUCCIÓN DE FRUTA Y MERCADEO

TODOS	2.1	Usted corta, vende y/o compra pitayas? Seleccionar todas las opciones aplicables.			
		☐ Corta (hacer preguntas 2.2 – 2.4)	☐ Vende (hacer preguntas 2.5 - 2.31)	☐ Compra (hacer preguntas 2.32 – 2.37)	☐ No (ir a 2.39.1)
Preguntas de <u>CORTA</u>					
TODOS	2.2	Cuántos días aproximadamente duró la producción de fruta este año?			días
PPA, PS, CS	2.3.1	Cuántas frutas cortó este año aproximadamente?			frutas
	2.3.2	Esto fue más, menos o similar al año pasado?	1. Más (ir a 2.3.3)	2. Menos (ir a 2.3.3)	3. Similar (ir a 2.4)
	2.3.3	Si MÁS o MENOS , a qué cree que se deba esta diferencia?	1. Clima	2. Plagas/enfermedades	3. Otro
	2.3.4	Favor de dar más detalles: (<i>ej. más o menos lluvia? Temperaturas más cálidas o frías?</i>)			
PPA, PS, CS	2.4	Qué porcentaje (%) de la fruta es:			
		1. vendida:	2. regalada:	3. perdida: (<i>No cosechada</i>)	4. Para consumo de vivienda:
Preguntas de <u>VENTA</u>					
TODOS	2.5	Qué tan seguido vende pitayas/productos durante la temporada de producción de frutas?			
		1. Todos los días	2. Algunas veces a la semana	3. Una vez por semana	4. Menos de una vez a la semana
		5. Cuando necesito dinero	6. Cuando tengo demasiadas pitayas	7. Otro (especificar):	
PPA, PS, CS, VC, VM, I	2.6.1	Vende los pitones de la pitaya (flores secas)?		1. Si (ir a 2.6.2)	2. No (ir a 2.7)
	2.6.2	Si SI a 2.6.1 , cuántas flores vende por día en promedio?			
	2.6.3	Si SI a 2.6.1 , en cuánto vende las flores?		pesos	
HP	2.7	Qué productos hace?			
		1. Ponche	2. Mermelada	3. Nieve	4. Gelatina
		6. Pan de pitaya	7. Yogurt	8. Otro (especificar):	
HP, VC, VM, I,	2.8	Cuántos productos vende diariamente en promedio?			
		1. Ponche:	2. Mermelada:	3. Nieve:	4. Gelatina:
		6. Pan de pitaya:	7. Yogurt:	8. Otro (especificar):	
HP, VC, VM, I	2.9	Cuál es el precio de los productos que vende?			
		1. Ponche:	2. Mermelada:	3. Nieve:	4. Gelatina:
		6. Pan de pitaya:	7. Yogurt:	8. Otro (especificar):	
VC, VM	2.10	Cuánto del precio de venta queda con usted? <i>A veces, los puestos venden los productos de otros por una comisión.</i>			
		1. Ponche:	2. Mermelada:	3. Nieve:	4. Gelatina:
		6. Pan de pitaya:	7. Yogurt:	8. Otro (especificar):	
HP	2.11	Dónde (lugar geográfico) se venden los productos a los consumidores? (especificar lo más posible): <u>Si los productos van a más de un lugar, estimar la proporción de los productos vendidos en cada lugar.</u>			

PPA, PS, CS, VC, VM, I	2.12	Dónde (lugar geográfico) se venden las frutas a los consumidores? (especificar lo más posible): <u>Si las frutas van a más de un lugar, estimar la proporción de la fruta vendida en cada lugar.</u>											
VC, VM, I,	2.13	Cómo vende la fruta?											
		1. Puesto en carretera		2. Puesto en mercado		3. En un carro		4. Otro (especificar):					
HP	2.14	Cómo vende los productos?											
		1. Puesto en carretera		2. Puesto en mercado		3. Puesto de alguien más		4. Otro (especificar):					
PPA, PS, CS, VC, VM, I	2.15	Por qué eligió vender la fruta/productos en la manera que lo hace?											
VC, VM, I, HP	2.16.1	Necesita un permiso en donde vende pitayas/productos actualmente?				1. Si (ir a 2.16.2)		2. No (ir a 2.17.1)					
	2.16.2	Si SI , por cuánto tiempo es el permiso?											
PPA, PS, CS, VC, VM, I	2.17.1	Cuántas frutas vendió esta temporada aproximadamente?						Frutas					
	2.17.2	Fué más, menos o similar al año pasado?				1. Más		2. Menos		3. Similar			
	2.18.1	Cuantas frutas vendió en pro medio por día esta temporada? Anotar abajo.											
		Inicio de temporada:			Durante la privanza:			Fin de temporada:					
	2.18.2	Cómo varían los precios entre tamaños, hora del día o momento de la temporada? Anotar los precios abajo											
		Inicio de temporada:		Durante la privanza:		Fin de temporada:							
		1. día (am)		2. tarde (pm)		3. día (am)		4. tarde (pm)		5. día (am)		6. tarde (pm)	
		Chico:		Chico:		Chico:		Chico:		Chico:		Chico:	
		Mediano:		Mediano:		Mediano:		Mediano:		Mediano:		Mediano:	
		Grande:		Grande:		Grande:		Grande:		Grande:		Grande:	
TODOS	2.19.1	El precio que dá cambia dependiendo de quién compra la fruta/producto?						1. Si (ir a 2.19.2)		2. No (ir a 2.20.1)			
	2.19.2	Si SI a 2.19.1 , cómo? Dar detalles.											
	2.20	Quién determina el precio de las pitayas/productos que vende?				1. Comprador		2. Vendedor		3. Depende			
	2.21.1	Cómo se establece el precio de la pitaya/productos?				1. Regateo (ir a 2.25.2)		2. Predeterminado (ir a 2.26)					
	2.21.2	Si REGATEO , qué afecta el precio final acordado? Seleccionar todas las que aplican.											
		1. Demanda de comprador		2. Disponibilidad de la fruta		3. Otros productores		4. Hora del día		5. Otro (especificar):			
TODOS	2.22	Cuánto vendió en pesos en total esta temporada?						pesos					
TODOS	2.23.1	Cree que obtiene un precio justo por la venta de pitayas/productos?						1. Si (ir a 2.24.1)		2. No (ir a 2.23.2)			
TODOS	2.23.2	Si NO a 2.20.1 , por qué no?											
TODOS	2.24.1	Quién cree que obtiene las mejores ganancias de la venta de pitayas?											
TODOS	2.24.2	Por qué?											
TODOS	2.25.1	El precio de la pitaya fluctúa entre años?						1. Si (ir a 2.25.2)		2. No (ir a 2.26)			
TODOS	2.25.2	Cómo?											
TODOS	2.26	Quién compra las frutas/productos? Anotar un porcentaje del total de frutas vendidas en cada respuesta apropiada:											
		1. Intermediarios:		2.Vendedores en mercado:		3.Hacedores de productos:		4.Personas de paso:					
		5.Amigos/familia/conocidos:		6.Vendedores ambulantes:		7.Otro (especificar):							

ALL	2.27.1	Tiene contratos de venta pre-establecidos o tratos antes de la temporada de cosecha?			1. Si (ir a 2.27.2)	2. No (ir a 2.28)	
	2.27.2	Si SI , son verbales o escritos?			1. Verbales	2. Escritos	
	2.27.3	Si SI , que se especifica en estos acuerdos/contratos?					
		Seleccionar:		Detalles:			
		1.	Precio	pesos			
		2.	Cantidad de fruta/productos	productos	frutas		
		3.	Regularidad de la entrega	Cada:	☐ Día	☐ Semana	☐ Mes
		4.	Hora de entrega				
		5.	Fecha de entrega				
		6.	Tamaño de la fruta				
		7.	Variedad de la fruta				
		8.	Duración del contrato				
		9.	Formas de pago				
		10.	Penalizaciones	Si se selecciona, ir a 2.27.4			
ALL	2.27.4	Si SI a penalizaciones, que pasa si no puede hacer alguna entrega según el contrato? <i>Ej. Si la calidad de fruta es inadecuada.</i>					
PPA	2.28	Qué pasa si las ganancias de la venta de frutas no son suficientes para pagar la renta de la plantación?					
		1. El arrendatario asume las pérdidas		2. Reembolso parcial del dueño al arrendatario		3. El dueño reembolsa todo el dinero al arrendatario	
ALL	2.29.1	Le pagan de manera inmediata las frutas/productos que vende?			1. Si (ir a 2.30)	2. No (ir a 2.29.2)	
	2.29.2	Si NO a 2.29.1 , cuánto tardan en pagarle en promedio?			días		
ALL	2.30.1	Qué proporción de la fruta o productos no se vende? (<i>solo las frutas que fueron traídas para vender</i>)					
	2.30.2	Qué hace con la fruta/productos que no se venden?					
		1. Se regalan	2. Se tiran	3. Se utilizan para hacer productos	4. Se venden para hacer productos (ir a 2.13.3)		
ALL	2.30.3	Si se venden para hacer productos, cuánto le pagan por la fruta?			por fruta		

		Preguntas de <u>COMPRA</u>				
VC, VM, I, HP	2.32	Cómo consigue la fruta que vende/con la que hace productos?				
		1. Comprada (ir a 2.33)	2. Cosecha propia o de un familiar (ir a mercadeo)	3. Otro (especificar):		
VC, VM, I, HP	2.33	Si COMPRADA , a quién le compra la fruta? Seleccionar todas las opciones que aplican.				
		1. Miembro de la familia/amigo	2. Intermediario	3. Vendedor de carretera/mercado	4. Propietario de solar	
		5. Directo de la plantación	6. Desconocido	7. Otro (especificar):		
VC, VM, I, HP	2.34	Si COMPRADA , de dónde (lugar geográfico) proviene la fruta y en qué proporción ?				
	2.35	Si COMPRADA , cuánta fruta compró este año?				frutas
	2.36.1	En total, cuánto pagó por pitayas este año?				
	2.36.2	Esto fue más, menos o similar al año pasado?		1. Más	2. Menos	3. Similar

	2.37	Esto varía entre tamaños, hora del día/momento de la temporada? Dar detalles abajo.				
		Inicio de temporada:		Durante la privanza:		Fin de temporada:
		1. día (am)	2. tarde (pm)	3. día (am)	4. tarde (pm)	5. día (am)
		Chico:	Chico:	Chico:	Chico:	Chico:
		Mediano:	Mediano:	Mediano:	Mediano:	Mediano:
		Grande:	Grande:	Grande:	Grande:	Grande:

TODOS		Preguntas de MERCADEO			
TODOS	2.38.1	Usted promociona sus frutas/productos? <i>Ej. difusión, buscar oportunidades de venta, etc.</i>			1. Si (ir a 2.38.2)
	2.38.2	Si SI , cómo?			2. No (ir a 2.39.1)
	2.39.1	Cuáles son los principales retos que su negocio/trabajo con las pitayas enfrenta? <i>Ej. Aumento de costos, falta de trabajadores capacitados, aumento de competencia, disminución de demanda o precios de venta, robo de frutas, plagas.</i>			
	2.39.2	Cómo lidia con estos problemas? (<i>ej. seguro, tener otras actividades económicas</i>)			

PPA	<u>Si el entrevistado es propietario de una plantación que la renta a alguien más, o si es arrendatario de plantación</u>				
PPA	2.40.1	Le pagan/paga usted un precio predeterminado o con una porción de las ganancias?	1. Precio predeterminado (ir a 2.40.2)	2. Porción de las ganancias (ir a 2.40.3)	
PPA	2.40.2	Si PRECIO PREDETERMINADO , cómo lo calcula?			
PPA	2.40.3	Si PROPORCIÓN DE GANANCIAS , cómo lo calcula?			
PPA	2.41	Cuánto le pagan/paga usted por año?		pesos	frutas
PPA	2.42	Le renta a/de la misma persona cada año?		1. Si	2. No
PPA	2.43.1	Hace un contrato con la persona que a la que le renta la plantación?		1. Si (ir a 2.43.2)	2. No (brincarse 2.43.2)
PPA	2.43.2	Es escrito o verbal?		1. Escrito	2. Verbal
	2.43.3	Si SI , que se especifica en ese contrato?			



7



Ahora haremos unas preguntas sobre quién hace cada trabajo con las pitayas. Es importante saber quién ayuda aunque no reciban salario.

TODOS	3. TIEMPO Y USO DE MANO DE OBRA
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		Tarea	Persona	Número de personas	Horas/día/persona trabajadas	Días/año trabajados
PPA, PS, TA	3.1	Actividades de manejo ej. Aplicación de pesticidas, rotación de suelo	Dueño de plantación			
			Arrendatario de plantación			
			Miembros de la familia			
			Empleado pagado (todo el año)			
			Empleado pagado (temporal)			
			Otro (especificar):			
TODOS	3.2	Corta de frutas	Dueño de plantación			
			Arrendatario de plantación			
			Miembros de la familia			
			Empleado pagado (todo el año)			
			Empleado pagado (temporal)			
			Otro (especificar):			
TODOS	3.3	Pela de frutas	Dueño de plantación			
			Arrendatario de plantación			
			Miembros de la familia			
			Empleado pagado (todo el año)			
			Empleado pagado (temporal)			
			Otro (especificar):			
TODOS	3.4	Ventas	Dueño de plantación			
			Arrendatario de plantación			
			Miembros de la familia			
			Empleado pagado (todo el año)			
			Empleado pagado (temporal)			
			Otro (especificar):			



Ahora haremos preguntas para describir de manera detallada los costos asociados con el trabajo de la pitaya. Esta información es muy importante ya que nos permitirá entender los ingresos promedios atribuibles a las pitayas en Techaluta.

TODOS		4. COSTOS		
Tipo de costo:				Costo en pesos/temporada
TODOS	4.1	Tierra/plantación(es)	Renta	
PPA, PS	4.2.1	Manejo/aporte	Pesticidas	
	4.2.2		Fertilizantes	
	4.2.3		Herbicidas	
	4.2.4		Composta	
	4.2.5		Brazos de pitaya/semillas	
	4.2.6		Otro (especificar)	
TODOS	4.3.1	Mano de obra	Compensación a miembros de la familia	
	4.3.2	<i>(Corrobore las respuestas con la sección 3)</i>	Trabajadores permanentes-salarios	
	4.3.3		Trabajadores temporales-salarios	
	4.3.4		Pagos de seguro social, medicinas, doctor	
	4.3.5		Otros beneficios, ej. comidas	
TODOS	4.4	Certificación	Certificación	
TODOS	4.5.1	Impuestos	Exportación	
	4.5.2		Producción	
	4.5.3		Ingresos	
	4.5.4		IVA	
	4.5.5		Tierra/propiedad (predial)	
VC, VM	4.6.1	Mercadeo	Renta de puesto	
	4.6.2		Almacenamiento	
	4.6.3		Cuota del Mercado, permiso de venta	
TODOS	4.7.1	Transporte	Seguro de vehículo	
	4.7.2		Gasolina	
	4.7.3		Mantenimiento de vehículo	
	4.7.4		Transporte público (ej. al y del trabajo)	
	4.7.5		Casetas	
TODOS	4.8.1	Equipo y herramientas	Compra de equipos y herramientas	
	4.8.2		Mantenimiento de equipos y herramientas	
	4.8.3		Empaque (ej. alfalfa, bolsas o envoltura plástica)	
TODOS	4.9.1	Finanzas	Pagos de créditos (formal o informal) e intereses para su trabajo con las pitayas	
	4.9.2		Pagos de seguro agrario para su(s) pitayera(s)	
		TOTAL		

HP		HACEDORES DE PRODUCTOS SOLAMENTE: COSTOS: FAVOR DE LISTAR TODOS LOS PRODUCTOS QUE SE HACEN, EL TIEMPO Y COSTOS DE MANUFACTURA DE CADA UNO			
		Nombre del producto <i>(Corroborar respuestas con 2.7)</i>	Tiempo para hacer el producto <i>Unidad?</i>	Cuántos se pueden hacer a la vez? <i>Unidad?</i>	Costo en pesos de los ingredientes del producto (incluyendo las pitayas)
HP	4.10				
HP	4.11				
HP	4.12				
HP	4.13				
HP	4.14				
HP	4.15				
HP	4.16				

TODOS		TODOS LOS ENTREVISTADOS:			
		4. FINANZAS			
TODOS	5.1.1	Tiene acceso a sistemas de crédito para empezar, crecer o mejorar su negocio?	3. No sé, no me interesa	1. Si	2. No
	5.1.2	Tiene acceso a alguna otra forma de financiamiento (informal)?		1. Si	2. No
TODOS	5.2.1	Alguna vez has recibido alguna asistencia financiera para su negocio de pitayas por parte del gobierno?		1. Si (ir a 5.2.2)	2. No (ir a 5.3)
	5.2.2	Si SI , dar más detalles (ej. subsidios, préstamos, incentivos)			
PPA	5.3	Cómo ha financiado el crecimiento o establecimiento de su producción pitayera?			
		1. Ganancias de cultivos de pitaya ya existentes	2. Venta de ganado	3. Remesas de Estados Unidos	
		4. Asistencia financiera o crédito	5. Otro (especificar):		
		➡ Ir a la sección 6 (organización grupal, capacitación y gobierno)			

 Ahora le haré unas preguntas sobre la organización de la comunidad y cualquier ayuda no-financiera que haya recibido del gobierno.

TODOS		TODOS LOS ENTREVISTADOS: 5. ORGANIZACIÓN GRUPAL, CAPACITACIÓN, GOBIERNO			
TODOS	6.1.1	Es parte de alguna cooperativa, asociación, agrupación o unión de comerciantes?	1. Si (ir a 6.1.2)		2. No (ir a 6.1.3)
	6.1.2	Si SI a 6.1.1 , favor de nombrarla(s)			
	6.1.3	Si SI a 6.1.1 , por qué es miembro? <i>(ej. hay más posibilidades de recibir apoyos del gobierno cuando se es parte de un colectivo)</i>			
		Si NO a 6.1.1 , por qué no es miembro? (ir a 6.2)			
	6.1.4	Si SI a 6.1.1 , le ha ayudado?	1. Si		2. No
6.1.5	Dar un ejemplo. Si SI , por qué sí? Si NO , por qué no?				
TODOS	6.2	Vende frutas/productos de manera colectiva?	1. Si		2. No
TODOS	6.3.1	Qué opina del nivel de organización en Techaluta de Montenegro para mejorar las condiciones o proveer más oportunidades para las personas que trabajan con pitayas?	1. Bueno	2. Regular	3. Malo
TODOS	6.3.2	A qué cree que se deba?			

TODOS	6.4.1	Alguna vez ha recibido capacitación en temas relacionados a negocios?	1. Si	2. No (ir a 6.5.1)
TODOS	6.4.2	Si SI , dar detalles (qué tipo de capacitación? <i>Ej. para hacer productos, composta</i>)		
	6.4.3	Quién promovió u organizó esa capacitación?		
TODOS	6.5.1	Qué tecnología o equipo necesita para llevar a cabo su trabajo?		
TODOS	6.5.2	Tiene acceso a estas tecnologías o equipo?	1. Si (ir a 6.6)	2. No (ir a 6.5.3)
TODOS	6.5.3	Si NO a 6.5.2, por qué no?		
TODOS	6.6	El gobierno local ha tomado acciones que le han ayudado O le han obstaculizado el trabajo con las pitayas? Dar detalles		
TODOS	6.7.1	Cómo cree que el sector pitayero podría mejorar para mejorar las condiciones de trabajo y expandir los mercados?		
TODOS	6.7.2	Quién cree que debería estar a cargo de eso?		
➡ C, P, L: Ir a la sección 7 (ingresos y condiciones de trabajo) ➡ PPA, VM, VC, PS, CS, HP, I: Ir a la sección 8 (percepción de los murciélagos)				



Ahora quisiera hacerle unas preguntas sobre sus ingresos y condiciones de trabajo. Toda la información que dé permanecerá confidencial y no será compartida con ninguna otra persona ni organización.

C, P, CH, VA, TA		CORTADORES (C), PELADORES (P), CHOFERES (CH), VENDEDORES ASALARIADOS (VA), TRABAJADORES AGRICOLAS (TA)				
6. INGRESOS Y CONDICIONES DE TRABAJO						
TODOS	7.1	Cuántos días de esta temporada de producción de frutas trabajó?				días
TODOS	7.2.1	Fue más, menos o similar al año pasado?	1. Más	2. Menos	3. Similar (ir a 7.3)	
TODOS	7.2.2	Si MÁS o MENOS a la pregunta 7.2.1, a que cree que se deba esa diferencia? (ej. menos/más trabajo disponible, consiguió otro trabajo, etc.)				
TODOS	7.3	Trabaja durante todo el año (cualquier trabajo) o sólo durante la temporada de pitayas?		1. Todo el año	2. Temporada	
C, P, Ch	7.4	Trabaja para una plantación, en casa propia o de alguien más?	1. Plantación	2. Casa propia	3. Casa de alguien más	
C, P	7.5	Recibe algún pago por pelar/cortar?		1. Si (ir a 7.6)	2. No (ir a la sección 8)	
C, P, Ch, TA	7.6	Si trabaja para una plantación, por cuanto tiempo ha trabajado en la plantación que labora actualmente?				años
TODOS	7.7.1	Tiene un contrato de trabajo?		1. Si	2. No	
TODOS	7.7.2	Si SI a 7.7.1, es verbal o escrito?		1. Verbal	2. Escrito	
TODOS	7.7.3	Si SI a 7.7.1, que se especifica en el contrato? Seleccionar todas las opciones que aplican.				
		1. Horas de trabajo	2. Tarifa de pago	3. Temporalidad de pago	4. Derecho a vacaciones	
		5. Incapacidad por enfermedad	6. Otro (especificar):			
TODOS	7.8.1	Cuánto le pagan (pesos)? <u>Llenar las tres opciones.</u>	por hora	por día	por semana	
TA	7.8.2	Cuánto le pagan (pesos) para el trabajo agrícola fuera de la temporada? <u>Llenar las tres opciones.</u>	por hora	por día	por semana	
TODOS	7.9	Hay opción de trabajar más de un turno si lo solicita? Dar detalles.				
TODOS	7.10	Los salarios varían entre plantaciones/puestos (para vendedores)?	1. Si	2. No	3. No sé	
TODOS	7.11	Recibe comidas gratuitas en su trabajo?	1. Si		2. No	
TODOS	7.12	Con cuánto tiempo de anticipación sabe si habrá trabajo para usted?	días			
TODOS	7.13	Si se enferma, aun así le pagan?	1. Si		2. No	
TODOS	7.14.1	Si pudiese trabajar en algún otro lugar, lo haría?	1. Si (ir a 7.14.3)		2. No (ir a 7.14.2)	
TODOS	7.14.2	Si NO a 7.14.1, por qué? Seleccionar todas las opciones que aplican. Luego pasar a 7.15.3.				
		1. Conveniencia	2. Buen ambiente de trabajo	3. Buena paga	4. Buen horario	
		5. Oportunidades para progresar	6. Seguro	7. Otro (especificar):		
TODOS	7.14.3	Si SI a 7.14.1, por qué? Seleccionar todas las opciones que aplican.				
		1. Inconveniente	2. Mal ambiente de trabajo	3. Baja paga	4. Largas horas de trabajo	
		5. Pocas o sin oportunidades de progresar	6. Inseguro	7. Otro (especificar):		
TODOS	7.15.1	Cree que algún día posea o rente alguna pitayera para producir sus pitayas?		1. Si (saltar 7.17.2)	2. No (ir a 7.17.2)	
	7.15.2	Si NO a 7.15.1, por qué no?				

➡ Ir a la sección 8 (percepción de los murciélagos)



Ahora me gustaría preguntarle algunas cosas para saber su opinión sobre los murciélagos.

TODOS	TODOS LOS ENTREVISTADOS: 7. PERCEPCIÓN DE LOS MURCIÉLAGOS			
TODOS	8.1	¿Cuántas especies de murciélagos piensa que hay en México?	especies	
TODOS	8.2.1	¿De estas especies, cuántas piensa que son beneficiosos a las personas, y cuantos perjudicial?		
		beneficiosos	perjudicial	
TODOS	8.2.2	¿Porque piensa que son buenos o malos?		
TODOS	8.3	Nombre de todas las cosas de que piensa se alimentan los murciélagos.		
TODOS	8.4.1	¿Piensa que los murciélagos comen las pitayas?	1. Si	2. No
TODOS	8.4.2	Si SI , que proporción de la cosecha cree que se comen?	%	
TODOS	8.5.1	Toma alguna medida para proteger a las pitayas de los murciélagos?	1. Si (ir a 8.5.2)	2. No (ir a 8.6)
TODOS	8.5.2	Si SI , cuáles? (ej. <i>Cortar las frutas en un momento específico, matar a los murciélagos</i>)		
TODOS	8.6	¿Sabía que los murciélagos polinizan las pitayas antes de saber de nuestro trabajo en Techaluta?	1. Si	2. No
TODOS	8.7	¿Piensa que los murciélagos deben ser protegidos?	1. Si	2. No
		➡ Continuar con la sección 8.2 (pitayas)		

TODOS	TODOS LOS ENTREVISTADOS: 8.2 PITAYAS			
TODOS	8.8.1	Come pitayas?	1. Si (ir a 8.8.2)	2. No (ir a 8.9)
TODOS	8.8.2	Si Si , por qué?	1. Calorías	2. Nutrición
			3. Otro (especificar):	
TODOS	8.9	Cree que las pitayas son parte importante de su dieta? Asigne un número en una escala del 1 al 5, dónde 1 es muy importante y 5 nada importante)		
		➡ Ir a la sección 9 (características socioeconómicas del hogar)		



Para terminar, me gustaría hacerle algunas preguntas sobre algunos detalles personales, algunas características de su hogar y sus ingresos.

TODOS	TODOS LOS ENTREVISTADOS: 9. CARACTERÍSTICAS SOCIOECONÓMICAS DEL HOGAR			
TODOS	9.1	Sexo:	1. Hombre 2. Mujer	
TODOS	9.2	Edad:	años	

TODOS	9.3	Número de personas (incluyendo todos los niños y adultos) viviendo en la casa:				
		Menos de 15 años		Entre 15-64 años		65 o más años
TODOS	9.5	¿Cuántas personas en su vivienda tienen trabajos pagados?				personas
TODOS	9.6.1	¿Cuántos trabajadores migrantes hay en su vivienda?				personas
TODOS	9.6.2	¿Cuántos miembros cercanos de su familia están trabajando en los EU?				personas
TODOS	9.7	¿Cuántas personas en su vivienda trabajan con pitayas?				personas
TODOS	9.8	Cuántos años ha trabajado con las pitayas?				años
TODOS	9.9	Si aplica, cuál era su trabajo previo?				
TODOS	9.10	¿Cuál es el ingreso mensual en su vivienda en pesos? (Si el entrevistado lo prefiere, puede elegir de las opciones de abajo).				
		☐ \$0-2,500	☐ \$2,500-5,000	☐ \$5,000-7,500	☐ \$7,500-10,000	☐ \$10,000-12,500
		☐ \$12,500-15,000	☐ \$15,000-20,000	☐ \$20,000-30,000	☐ \$30,000-40,000	☐ \$50,000 +
TODOS	9.11	La pitaya es la principal fuente de ingresos en su vivienda?				1. Si 2. No
TODOS	9.12	Qué porcentaje de su ingreso promedio anual proviene de la pitaya?				
		1. 0-20%	2. 20-40%	3. 40-60%	4. 60-80%	5. 80-100%
TODOS	9.13	Qué otras fuentes de ingresos tienen en su vivienda?				
TODOS	9.14	Usted cree que los ingresos provenientes de la pitaya le permiten tener lo necesario para vivir?				1. Si 2. No
TODOS	9.15	Qué hace con el ingreso de la pitaya? Seleccionar todas las opciones aplicables				
		1. Ahorrarlo	2. Comprar bienes materiales (ej. muebles)		3. Invertirlo (tierra, animales, equipo, etc.)	
		4. Para la escuela de los hijos	5. Comprar comida y cosas para la casa (ej. limpieza)		. Pagar renta y gastos del hogar	
		7. Otro (especificar):				
TODOS	9.16	¿Cuál es el año o grado más alto que estudió?				
		1. Primaria	2. Secundaria	3. Carrera técnica con secundaria terminada		
		4. Preparatoria o bachillerato	5. Licenciatura	6. Posgrado		
TODOS	9.17	¿Cuál es el año o grado más alto que alguien en su vivienda estudió?				
		1. Primaria	2. Secundaria	3. Carrera técnica con secundaria terminada		
		4. Preparatoria o bachillerato	5. Licenciatura	6. Posgrado		
TODOS	9.18	De qué material es la mayor parte de las paredes de su vivienda?				
		1. Material de desecho	2. Lámina de cartón	3. Lámina de asbesto o metálica		
		4. Carrizo, bambú, o palma	5. Embarro o bajareque	6. Madera		
		7. Adobe	8. Tabique, ladrillo, block, piedra, cantera, cemento o concreto			
TODOS	9.19	¿Cuantos cuartos tiene su vivienda incluyendo la cocina, el baño y la sala?				cuartos
	9.20	¿De qué material es el suelo de su vivienda?				
TODOS	9.21	En los últimos tres meses, por falta de dinero o recursos ¿alguna vez se quedaron sin comida?				1. Si 2. No
TODOS	9.22	¿Tiene un vehículo o acceso a un vehículo?				1. Si 2. No
TODOS	9.23	¿Tiene un teléfono celular?				1. Si 2. No



Este es el fin de la encuesta, muchas gracias por su tiempo. Hay algo más que le gustaría agregar o preguntarnos?

Nuestra información de contacto la puede encontrar en la hoja que le he dejado. Si quisiera enterarse de los resultados de este trabajo, por favor, no dude en contactarnos.

Conoce a alguien más que trabaje con pitayas que cree quisiera también participar en nuestras encuestas? Si es así, me podría pasar algún dato para poder contactarlo(a)? (Anotarlo en un cuaderno por separado)

Finalmente, podría reconfirmar que está totalmente de acuerdo en que usemos esta información que nos acaba de proveer para nuestro trabajo, tal como lo especificamos al inicio de esta entrevista?

ENCUESTA PARA CONSUMADORES

⇒ **LEER LA PAGINA DE INFORMACION**⇒ **LEER LA PAGINA DE CONSENTIMIENTO Y PEDIR LA FIRMA DEL PARTICIPANTE**

Muchas gracias. Ahora empezamos la entrevista. Esta hecho de secciones diferentes que se preguntan de cómo y cuándo compra o come fruta. La entrevista debería tomar aproximadamente 15-20 minutos para cumplir.

ESTE PARTICIPANTE COMPRA PITAYAS PARA COMER:		Numero de entrevista:
Fecha de entrevista:	Hora de empieza:	Consentimiento obtenido: S/N
Nombre de entrevistador:	Hora de terminar:	Locación:

CODIGO	1. COMPRAR Y CONSUMER DE FRUTA
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2.44	Porque compra pitayas? Circulo todos los números que se aplican.					
	1. Sabor	2. Aspecto	3. Hambre	4. Antojo	5. Contenido nutricional	6. Otro:
3.38	Con que frecuencia compra pitayas?					
	1. Todos los días		2. Unas veces por semana		3. Una vez por semana	
	5. Una vez por mes		6. Menos a menudo		7. Otro:	
3.39	¿Cuántas pitayas compra cada vez en promedio?					
2.36.1	¿Cuánto pagó por pitaya este año en promedio?					pesos
2.36.2	¿Fue más, menos o igual que el año pasado?				1. Mas	2. Menos
					3. Igual	
2.37	¿El precio varía entre las variedades y tamaños? Dar detalles abajo.					
	Mamey Chico: Mediano: Grande:		Blanco Chico: Mediano: Grande:		Tenamaxtle Chico: Mediano: Grande:	
	Morado Chico: Mediano: Grande:		Amarillo Chico: Mediano: Grande:		Rojo Chico: Mediano: Grande:	
					Silvestre Chico: Mediano: Grande:	
					Other (specify): Chico: Mediano: Grande:	
2.45.1	¿Prefería comprar una variedad en particular?					1. Si
						2. No
2.45.2	¿Si SI a 2.34.1, cual y porque?					
2.23	¿Quién pone el precio de las pitayas que compra?				1. Comprador	2. Vendedor
2.24.1	¿Cómo es el precio de las pitayas establecido?				☐ Regateo (ir a 2.24.2)	☐ Pre-determinado (ir a 2.25.1)
2.24.2	¿Si REGATEO, que afecta el precio final?					
	1. Demanda de comprador		2. Disponibilidad		3. Otros vendedores	
			4. La hora		5. Otro (dar detalles):	
2.25.1	¿El precio de la pitaya varia a través de la temporada?				1. Si (ir a 2.25.2)	2. No (ir a 2.46)
2.25.2	¿Si SI a 2.25.1 que es lo más que ha pagado por una pitaya?				pesos	
2.25.3	¿Por qué pagó este precio?					
2.56	¿Qué es el característico lo más importante cuando compra las frutas?					

ENCUESTA PARA CONSUMADORES

	1. Sabor	2. Aspecto	3. Color	4. Tamaño	5. Otro (dar detalles):
2.46	¿La disponibilidad de la pitaya varía entre años?				1. Si 2. No
2.46	¿De quién compra las frutas o los productos? Marque todas las que se aplican.				
	1. Familiar	2. Comerciante	3. Vendedor de carretera	4. Dueño de cactus de casa	
	5. De plantación	6. Vendedor de mercado	7. Otro (dar detalles):		
2.47	¿De cuántas personas diferentes compra las pitayas?				
	1. 1	2. 2-5	3. 6-10	4. 11-15	5. 16+
2.48	¿Compra las pitayas de los mismos vendedores cada año?				1. Si 2. No
2.34.1	¿ De dónde (ubicación geográfica) vienen las frutas que compra?				
2.49.1	¿ De dónde (ubicación geográfica) ha venido para comprar pitayas?				
2.49.2	¿Hasta dónde ha viajado para comprar pitayas?		☐ km ☐ horas ☐ minutos		
2.49.3	¿ Como ha viajado para comprar pitayas?		1. Carro	2. Caminar	3. Bus 4. Metro
2.50.1	¿Piensa que las pitayas forman una parte importante de su dieta?				1. Si (ir a 2.50.2) 2. No (ir a 2.50.3)
2.50.2	¿Si SI a 2.50.1, porque? Marque todas las que se aplican.				
	1. Sabor	2. Contenido nutricional	3. Importancia cultural	4. Otro (dar detalles):	
2.50.3	¿Si NO a 2.50.1, porque no?				
2.51	¿Compra productos derivados de pitayas?				1. Si 2. No
2.52	¿Con qué frecuencia compra productos derivados de pitaya?				
	☐ Todos los días	☐ Unas veces por semana	☐ Una vez por semana	☐ Una vez por 15 días	
	☐ Una vez por mes	☐ Menos a menudo	☐ Otro:		
2.53	¿Cuáles productos compra?				
	☐ Ponche	☐ Mermelada	☐ Nieve	☐ Gelatina	☐ Rompope
	☐ Pan de pitaya	☐ Flores	☐ Otro (dar detalles):		
2.54	¿Cuánto paga por productos?				
	Ponche:	Mermelada:	Nieve:	Gelatina:	Rompope:
	Pan de pitaya:	Maquillaje:	Otro:		
2.55	¿Que haría si pitayas y productos derivados de pitaya no fueran disponible o asequible toda vía?				



Ahora queremos preguntarle de lo que sabe y piensa de murciélagos.

CODIGO	8. PERCEPCIONES DE MURCIELAGOS		
8.1.1	¿Cuántas especies de murciélagos piensa que hay en México?		murciélagos
8.2.1	¿De estas especies, cuántas piensa que son beneficiosos a las personas, y cuántos malos?		Buenos Malos
8.2.2	¿Porque piensa que son buenos o malos?		
8.3	Nombre de todas las cosas de que piensa se alimentan los murciélagos.		
8.4	Piensa que los murciélagos comen las pitayas?		☐ Si ☐ No

ENCUESTA PARA CONSUMADORES

8.6	¿Supo que los murciélagos polinizan las pitayas?	☐ Si	☐ No
8.7	¿Piensa que los murciélagos deben ser protegidos?	☐ Si	☐ No



Finally, we would like to ask you some questions about your background and income.

CODIGO	9. SOCIO-ECONOMIC CHARACTERISTICS
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9.1	Sexo:	☐ Hombre	☐ Mujer
9.2	Edad:	años	
9.3	Número de personas (incluyendo todos los niños y adultos) viviendo en la vivienda:		
	Menos de 15 anos	Entre 15-64 anos	65+ años
9.25	¿Qué es su trabajo?		
9.4.1	¿Tiene pareja?	☐ Si	☐ No
9.4.2	¿Si SI , su pareja trabaja?	☐ Si	☐ No
9.4.3	¿Si SI , que es su trabajo?		
9.5	¿Cuántas personas en su vivienda tienen trabajos pagados?	personas	
9.6.1	¿Cuántos trabajadores migrantes hay en su vivienda?	personas	
9.6.2	¿Cuántos miembros cercanos de su familia están trabajando en los EU?	personas	
9.10	¿Qué es el ingreso anual de su vivienda? (Si participante prefiere, puede elegir de las opciones abajo – en pesos)		
	☐ \$0-50,000	☐ \$50,000-100,000	☐ \$100,000-150,000
	☐ \$150,000-200,000	☐ \$200,000-250,000	☐ \$250,000-300,000
	☐ \$300,000-350,000	☐ \$350,000-400,000	☐ \$400,000-450,000
	☐ \$450,000 +		
9.17	¿Cuál es el año o grado más alto al que asiste?		
	☐ Primaria	☐ Secundaria	☐ Carrera técnica con secundaria terminada
	☐ Preparatoria o bachillerato	☐ Licenciatura	☐ Posgrado
9.18	¿Cuál es el año o grado más alto al que alguien en su vivienda asiste?		
	☐ Primaria	☐ Secundaria	☐ Carrera técnica con secundaria terminada
	☐ Preparatoria o bachillerato	☐ Licenciatura	☐ Posgrado
9.19	De qué material es la mayor parte de las paredes o murales de esta vivienda?		
	☐ Material de desecho	☐ Lámina de cartón	☐ Lámina de asbesto o metálica
	☐ Carrizo, bambú, o palma	☐ Embarro o bajareque	☐ Madera
	☐ Adobe	☐ Tabique, ladrillo, block, piedra, cantera, cemento o concreto	
9.20	¿Cuántos cuartos tiene incluyendo la cocina, el baño y la sala?		
9.21	¿De qué material es el suelo de la esta vivienda?		
9.22	En los últimos tres meses, por falta de dinero o recursos ¿alguna vez se quedaron sin comida?	☐ Si	☐ No
9.23	¿Tiene un vehículo, o acceso a un vehículo?	☐ Si	☐ No
9.24	¿Tiene un teléfono celular?	☐ Si	☐ No



Eso es el fin de las preguntas que tenemos para preguntarle; muchas gracias por su tiempo.
¿Hay algo que quiere añadir o preguntar?

Detalles contactos están en la página de información que le hemos dado; si quiere saber las resultas o tiene algunas preguntas, por favor no dude en ponerse en contacto con nosotras.

Por fin, puede reconfirmar que nos da permiso para usar la información que nos ha dado para el proyecto, como al principio descrito a usted?