Commercial Farming of Leiolepis guttata in Binh Thuan **PROVINCE, VIETNAM: IMPLICATIONS FOR CONSERVATION AND** MANAGEMENT

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Abstract.—Since the first Indochinese war, natural populations of *Leiolepis guttata* have been hunted for their meat in southeastern Vietnam as a subsistence meal; nowadays, it has become a luxury delicacy. Commercial farms have become established since 2004 because of wild population declines and increasing demand for meat. We interviewed farmers and restaurateurs about the breeding and trade of the species to better understand the impact on wild populations. The results highlight the recent flourishing expansion of farming with rapidly increasing product prices and number of farms, as well as the ease and profitability of this activity. Wild population declines are widely acknowledged by authorities and local communities. Farms are being regarded as conservation pools to offset wild stock depletion, in addition to an important source of income. We discuss the risks associated with this trade development and we emphasize the conservation implications. Demand for lizards as founders for farms and for meat are likely to increase further, but risks exist that the development of new farms would saturate the market causing prices to ultimately fall. Habitat destruction and over-collecting severely reduce wild populations, but the high densities of farmed lizards raise serious genetic and sanitary issues. We suggest that further information should be collected to assess the sustainability of this trade. Priority should be given to the assessment of natural population densities and hunting effort. Biological patterns of this species are poorly documented and sound knowledge would enable better management of farms, and if this species is recognized as endangered could lead restrictions on harvesting of wild populations.

Key Words.—Agamidae; commercial farming; Giant Butterfly Lizard; southern Vietnam; wildlife trade

INTRODUCTION

precedented rates throughout the world. The (Milner-Gulland and Bennett 2003; Redmond et main factors attributed to this decline are the alter- al. 2006). Because reptiles often occur at high ation, destruction, and fragmentation of habitat, densities and biomass levels, they are particuunsustainable human use, global climate change, larly well-suited for management as a food rediseases, and impacts from invasive species and source (Klemens and Thorbjarnarson 1995). Al-

pollution (Gibbons et al. 2000). The wild meat trade alone has now overtaken habitat loss as the Reptile populations are being reduced at un- greatest threat to wildlife in the humid tropics

though many species of reptiles are consumed by humans, only some taxa undergo extensive consumption and the commercialization of their meat. Concern has been growing in recent years about the unsustainable levels of wildlife hunting, especially in tropical forests (Robinson and Bennett 2000). Wildlife hunting pressure has increased immensely and many exploited species are facing local or even global extinction (Milner-Gulland and Bennett 2003). Vietnam's natural environment, which supports one of the most biologically diverse ecosystems in the world, has deteriorated rapidly over the past decades. Twenty-one percent of its reptiles and amphibians species are endangered, mainly because of habitat loss and overexploitation (World Bank 2002). In Africa, meat from wild animals is considered as an important source of protein, but across much of Southeast Asia it is widely demanded as a specialty food or as additives to drinks and medicine (Nguyen 2003; Brooks et al. 2010). Facing wild population decline, captive breeding activities have arisen throughout Vietnam since 2000, encouraged by national action plans and supported by provincial directives as poverty alleviation schemes to improve local livelihoods (Thomson 2008). The ways in which natural resources are used by human populations are extremely relevant in defining successful conservation strategies (Alves et al. 2008). Sound biological knowledge is also essential to model sustainable use of resources. Southeast Asian biodiversity has been poorly documented over the last several decades in comparison with other tropical regions (Sodhi et al. 2004), especially with respect to amphibians and reptiles. Consequently, the population status of most species remains unknown (Sung et al. 2011). We document the commercial farming of the Giant Butterfly Lizard, Leiolepis guttata, in southern central Vietnam. This species is mainly herbivorous and is one of the eight known species of butterfly lizards (Leiolepidinae, Agamidae) originating from Southeast Asia. The range of this indigesix southeastern provinces (Ananjeva et al. 2007; Nguyen 2010; Tran et al. 2012). To date, the conservation status of this species has not been assessed. Leiolepis guttata was historically hunted largely for subsistence consumption by human populations during the first (1945-1954) and second (1954-1975) Indochinese wars. Its flesh was said to be healthy for wounded and weak people (Nguyen 2010). People continued eating these lizards after the war (Nguyen 2010). As hunting became more difficult due to decreasing natural populations and an increasing demand, farms appeared for the first time in 2004 in the Bac Binh District, southeastern Vietnam. Commercial farming of this lizard became progressively more popular, and the number of farms of L. guttata has increased notably (Bac Binh People's Committee, unpubl. report). Its meat is no longer consumed for subsistence but is now sold as a luxury product. In this paper we document the commercial farming of this lizard in the Bac Binh District. We present the geographical framework of the study, husbandry practices of farming, economic patterns, and trade dynamics. Based on our results and the socio-economical context, we discuss threats and conservation implications of this trade on wild populations. Considering that information about this species and its exploitation is scarce, we hope that the data presented here are useful in addressing issues relevant to long-term ecologically sustainable use of these lizards.

MATERIALS AND METHODS

with respect to amphibians and reptiles. Consequently, the population status of most species remains unknown (Sung et al. 2011). We document the commercial farming of the Giant Butterfly Lizard, *Leiolepis guttata*, in southern central Vietnam. This species is mainly herbivorous and is one of the eight known species of butter-fly lizards (Leiolepidinae, Agamidae) originating from Southeast Asia. The range of this indigeness of the species and the constant of the constant state of the constant state. The constant state of the constant state of

inhabitants (in 2010), with an average population density of 64 people per km², which is the lowest of all districts in the province. It is a predominantly agricultural district, and sandy soils and coastal sand dunes cover about 18% of the natural area of the province (Pham et al., unpubl. report). The area is characterized by a combination of tropical monsoon and dry and windy weather. It is the driest and hottest region of Vietnam. There are distinct dry and wet periods; the dry period lasting five months and beginning approximately in November. The monthly mean temperature oscillates between 20°C and 33°C. The annual average precipitation is 1,024 mm (at Phan Thiêt), while annual rainfall occasionally drops as low as 550 mm at some locations (Hountondji and Ozer 2011).

Data collection.—We collected information on lizard farming activity, consumption, and commercialization from February to June 2010 by interviewing farmers and restaurant owners. We focused on the Bac Binh District for farming surveys, as the first farms of L. guttata began there and this appears to be a central point of commercialization (Nguyen 2010; Bac Binh People's Committee, unpubl. report). We collected the most recent available official data for the repartition and number of farms in the district at the People's Committee. We visited 40 farms according to a proportional random-stratified sampling design, which takes into account the very unequal repartition of registered farms among the communes. We carried out structured questionnaires with mainly quantitative closed-ended questions (see appendices). The interviewed person was responsible for husbandry activity if present, or a closely related member aware of farm-related questions. In this context, the term farmer represents the interviewed person. We collected data on history and size of the farms, husbandry practices, economic and trade patterns, the origin and destination of the lizards, and wild stock. We haphazardly interviewed 21 restaurant owners

in four cities and villages from Binh Thuan Province chosen according to accessibility. The questionnaires included closed- and open-ended questions. Collected data were related to prices, trade, and recipes.

Analysis.-Frequencies of replies are expressed as percentages. As some questions embarrassed people or did not apply to some interviewees, the number of respondents varies between questions. Frequencies are therefore also presented as fractions of the total number of respondents. When numerical responses were required, if a range was given, we calculated statistics from its midpoint. We used a Pearson's correlation to observe the change of different parameters over time: frequency of farm startup dates, price trends, and hunting results. We converted all prices to US Dollars at the currency exchange rate for the corresponding year (OANDA. 2012. Historical currency exchange rates. Available from http://www.oanda.com [accessed 21 March 2012]), and adjusted them for inflation to the 2010 rate (CPI Inflation Calculator. US Bureau of Labor Statistics. Available from http://data.bls.gov/cgi-bin/cpicalc.pl [Accessed March 2012]). Once normality was tested on price categories, we compared the prices of different lizard products with one-way ANOVAs coupled with Tukey post hoc tests for pair-wise comparisons ($\alpha = 0.05$).

RESULTS

Farms.—In 2009, 244 farms were registered at the Bac Binh People's Committee (Bac Binh People's Committee, unpubl. report); 49.2% (120/244) were located in one single coastal commune, Hoa Thang, where the first farm settled in 2004, while none were observed in six of the 15 communes (Fig. 1). Most of the farms are located in coastal communes in sandy areas corresponding to the natural habitat of *L. guttata*. The number of farms is increasing rapidly and the People's Committee aims to multiply their



FIGURE 1. Giant Butterfly Lizard (*Leiolepis guttata*) farms located in the Bac Binh District of Vietnam (map based on data from Bac Binh Popular Committee, unpubl. report).

TABLE 1. Description of the number and area of commercial farms of the Giant Butterfly Lizard, *Leiolepis guttata*, in the Bac Binh District of Vietnam from 2007 to 2010 (taken from Bac Binh Popular Committee, unpubl. data).

Year	Farms (N)	Total area (m ²)
2007	142	119,560
2008	224	193,730
2009	244	259,000
June 2010	325	386,000
Expected for 2015		1,000,000

global area almost threefold by 2015 (Table 1). This recent increasing trend has also been observed in the surveys. The frequency of start-up dates significantly increases with time (r = 0.861, n = 40, P < 0.05), with only one farm built in 2004 and 72.5% (29/40) between 2007 and 2009.

The farms are composed of a fence bordering a sandy terrain, covered with no to dense vegetation. This vegetation provides shade and food for the lizards, which are able to climb. To avoid cannibalism, the terrain is divided in two different enclosures in most of the cases (29/40; 72.5%), such that juveniles and adults are separated. The total area ranges from 80 to 8400 m2, with a mean (\pm SE) of 967 \pm 253.1 m2. Once the terrain is ready, founders are introduced: a mix of males, females, and/or immature lizards of various proportions. The mean quantity to begin a farm ranges from five to 400 kg with a mean of 70.4 ± 11.27 kg (39 answers to questions), which corresponds to 287 lizards when considering mean weights cited by the farmers, with a mean of 26.8% of males.

The origin of founders.—Only two out of 40 (5%) farmers reported to have acquired their initial founders directly by hunting them in the wild. Farmers mainly buy all their founders from other farmers (18/40, 45%) without regard to whether they were captive raised or caught from the wild. Twenty-five percent (10/40) bought founders from hunters, while another 27.5%

(11/40) bought founders from both hunters and farmers. Altogether, 52.5% (21/40) of the farmers obtained at least part of their founders from wild populations. However, a logistic regression based on data from 2004 to 2009 indicated that the tendency to buy from hunters is strongly decreasing from one year to the next (P < 0.05, n occurrences of buying = 50; Fig. 2): the odds ratio between the probabilities to buy from a farmer and from a hunter is multiplied by 1.85 each year.

Husbandry practices and economics of farming.—When interviewed about the number of people taking care of the farm, eight out of 40 (20%) farmers spontaneously mentioned the low maintenance requirements associated with lizard farming. It requires most of the time one (19/40) to two (19/40) people to look after the farm. One to two hours of work per day are enough for feedstuff preparation (slicing and distribution). If not produced by the farmer, feedstuff is purchased at the market, together with household food. Twenty-three of 32 (71.9%) of the respondents feed the animals only once a day, in the morning, and the others a second time early afternoon. Once the lizards are fed, work is done until the following day. The most frequently distributed feedstuff consists of the leaves of Bindweed (Ipomoea aquatica, 37/40 respondents), and Pumpkins (Cucurbita maxima, 19/40 respondents). Only four of 40 (10%) respondents reported breeding lizards as their main activity. Agriculture (16/40) and animal husbandry (8/40) are often their main activities. Among the 26 non agriculture-related professions, the most frequently cited are mechanic, fisherman, People's Committee member, and catering (each: 4/26; 15.4%). The expenses related to the settlement of the farms include farm building and the acquisition of founder individuals. The costs to build the farm, which mainly consists of erecting a fence, range from \$155 to \$7,041 US (mean \pm SE of \$972 \pm 201.40 US, n = 40 respondents). The amount of money invested for the lizards ranges from



FIGURE 2. Percentage of purchases of the Giant Butterfly Lizard (*Leiolepis guttata*) made by farmers from hunters (light gray) and from other farmers (dark gray) from 2004 to 2009 in the Bac Binh District of Vietnam.

 $54 \text{ to } 6,443 \text{ US} \text{ (mean} = 911 \pm 207.40 \text{ US},$ n = 39). Once the farms are settled, the only daily expenses are related to feeding of lizards; 37.5% (15/40) of the farmers produce some of the food intended to be distributed to the lizards, with 7.5% (3/40) of them producing all of it. The mean price for food per day is 1.00 ± 0.20 US. After building the farm, farmers wait a mean = 1.4 ± 0.14 years (n = 34) for the farm to develop before the first sale. Reported annual income related to lizard farming activity ranges from \$52 to 3,660 US (mean = 9999 ± 157.80 US, n = 26), while reported annual income coming from the main profession ranges from \$627 to \$4,183 US (mean = $$2,286 \pm 156.60$ US, n = 31). One farmer stated that the general trend was that after one year, twice the amount initially invested was earned. The size and sex of lizards sold depend on the agreements between the purchaser and the seller. The proportion of male to female for founders is mainly random (19/21) if bought from hunters, depending on their captures. When bought from farmers, however, the proportion is most of the time predetermined (17/29). The mean proportion \pm SE is 2.7 \pm 0.15 males out of

10 lizards (n = 45 respondents), as more females are needed than males for reproduction. If not predetermined, the proportions are random (7/29)or only juveniles are sold by piece. Lizards destined for consumption are mainly composed of males and old sterile females. Eleven of 20 (55%) respondents reported to sell mainly meat lizards, four sold founders, and five sold both evenly depending on the demand (3/5) or the proportion of sexes (2/5). The main reason for selling founders is because the demand is higher (2/4), as well as the prices (2/4). Selling meat lizards is mostly to let the farm develop (9/11) and then to balance the ratio of males to females, as high proportions of males engender cannibalism. It is often preferred to sell males during the first years to allow the females to reproduce. The mean weight of sold lizards is 419.1 ± 16.39 g for males (n = 34) and 181.9 ± 12.20 g for females (n = 27). Once founders are acquired, farmers sell their lizards directly to consumers (12/40), retailers (24/40), other farmers (25/40), and/or restaurants (2/40). Retailers collect large quantities of lizards from farmers and hunters to resell them. They

sometimes appear in markets such as the Phan Thiet market. Restaurants buy their lizards from hunters (3/12; 14.3%), retailers (13/21; 61.9%), and/or farmers (11/21; 52.4%). Only 23.8% (5/21) of questioned restaurants bought from the same person each time and four of them stated that they were buying from several individuals alternately.

Trade dynamics.—A comparison of the data collected for prices (USD) from 2004 until 2010 of different lizard products indicates that there was a significant difference in price depending on product type ($F_{4,282} = 57.36$, P < 0.001, n = 283). Price for meat lizards from retailers was significantly higher than price for farmed founders (HSD, P < 0.05), which was significantly higher than meat lizards from farmers and retailers (HSD, P < 0.05). Wild founders were significantly cheaper than all other products (HSD, P < 0.05). For founders, farmers reported that a higher percentage of females increased the price per kilogram live-weight, but the correlation was not significant (P > 0.05). There was an increase in the value of lizards between 2004 and 2010 (Fig. 3). This was the case for both founders and meat lizards, from restaurants, hunters, retailers, and farmers. The lowest correlation was for wild founders (r =0.576; P < 0.05), while the greatest observed correlation was for meat lizards from restaurants (r = 0.730; P < 0.001). Of 31 reported places of purchase for founders, 29 farmers referred to the Hoa Thang commune. Among the farmers interviewed, 22 were themselves living in this commune. It is commonly thought that the lizards coming from this area are of better quality due to the properties of sand and the experience and age of the farmers. The origin of clients is mainly inside the province, but seven farmers cited other provinces. The ones coming from between 200 and 600 km away (Ho Chi Minh City, Hue, Mekong Delta, and Dong Nai) buy lizards for consumption or to breed, and ask for advice on farming practices. All (28/28) of the

respondents stated that the demand was very high, even too high to be satisfied. The most important demand is for founders. One single order may reach several hundreds of kilograms. We even heard a farmer being asked for 400 kg of lizards for a new farm and a second one who was offered a large sum of money for all his lizards. There are two periods of very high demand for farmers, which depend on the type of lizards sold. The first one lasts from January until February, with highest demand for meat lizards. In the lunar calendar, it corresponds to the New Year's celebration (Têt), which is the most important event of the year. The second period is from March until May, which coincides with the breeding period. The founders are most wanted during this period. The best periods for restaurants are between May and October, with maxima from July to September. July and August are summer school holidays in Vietnam and the months during which the area is most frequented by foreigners.

Consumption.—Former testimony of hunters confirms that lizards were a source of food during the war. Fourteen of 40 interviewed farmers (35%) had caught wild lizards previously, half of which were caught during the war. According to the hunters, the quantity of wild lizards found in one day in their natural environment has decreased dramatically. Based on cited quantities of daily lizards found over time, from the beginning of the war (1960) until 2010, there was a significant decrease in numbers of lizards over time (r = -0.817, P < 0.001), with a mean = 8.9 (± 1.54) kg live-weight of lizards per day from 1960 until 1980 (nine respondents) and 0.4 (\pm 0.08) kg between 2005 and 2010 (seven respondents; Fig. 4). As the price of lizards is quite high, farmers reported that consumers usually are well-off people, or occasional consumers, buying 1-2 kg of lizards for a celebration or as a gift. In restaurants, the principal consumers are foreigners (cited by 10 of 21 people interviewed at restaurants) and rich Vietnamese coming to



FIGURE 3. Changes in price per kilogram live-weight of different products of the Giant Butterfly Lizard (*Leiolepis guttata*) from 2004 to 2010 in the Bac Binh District of Vietnam. (Meat lizards from retailers: blue diamonds; Wild founders: red squares; Farmed founders: green triangles; Meat lizards from farmers: purple "×"; Meats lizards from restaurants: blue circles.)



FIGURE 4. Change in the quantity of the Giant Butterfly Lizard (*Leiolepis guttata*) hunted from the 1950s into 2010 in the Bac Binh District of Vietnam based on farmers in the area.

the seaside for the holidays (9/21), or officials as members of the People's Committee (8/21). The visited restaurants began to include lizards on their menus between 1990 and 2010, with the majority doing so after 2005 (11/21, 57.1%). The monthly quantities bought are variable, ranging from 1.5–90 kg, with a mean = 17 (\pm 4.9) kg. The global income generated by the lizards represents 7% on average, reaching 35% for some restaurants. They sell the product by the kilogram or dish, depending on circumstances and clients. The mean price per dish = \$7.00 (\pm 0.90) US. We were told of 30 recipes that use lizards as meat.

DISCUSSION

This study highlights the recent and growing development of *Leiolepis guttata* farms in the Bac Binh district, associated with a rapid increase in prices and demand. While 244 farms were registered at the Bac Binh People's Committee in 2009, this number should be considered an underestimate of the true number; many farms are not listed, which was confirmed by the fact that of 40 randomly visited farms, 13 did not appear on the official records. We recorded fast growth of L. guttata farming activity over recent years which seems to be linked to an increasing demand for meat lizards and even more for founders. Considering the quick progression of the standard of living in Vietnam, this species may be more frequently consumed and requested for its meat. The meat, which was first a subsistence meal during the war, has become a luxury and delicacy. The consumption of wildlife is part of the Vietnamese culture and this lizard is recognized for its pharmaceutical properties (although this has never been demonstrated scientifically). Its meat is thought to increase the resistance of the body to tiredness and to benefit the health of sick and elderly people. It is said to have healing properties for asthma, rheumatism, fever, cough, flu, paralysis, headaches, bone problems, and impotence (Bac Binh People's Committee, unpubl. report; Nguyen 2010). After becoming a luxury product for local people, it became valued and appreciated by tourists as well (Nguyen 2010). Recent tourism development in the region could also contribute to an increasing demand for lizard meat. Hoa Thang, where half of the farms in the district are located, is 30 km from Mui Ne, a popular touristic locality with sandy beaches. Tourists who frequent this area often enjoy eating luxury and meat dishes including snake and turtle. Lizards are not very popular yet, but many people are surprised by its unusual and good taste (Nguyen 2010). Farmers stated that demand was even higher for founders and the following factors make us predict that the number of farms starting up every year is likely to increase further. Low maintenance requirements and the ease with which lizards are bred were highlighted by the farmers. The lack of experience in raising wild animals is generally considered to be problematic in wildlife farming (Mockrin et al., unpubl. report), but in our case, farming experience is transmitted from person to person, and everyone seems to be satisfied with their own practices. Frequently, poorer people, or those not having access to a large quantity of land, simply transform part of their garden into a farm. Nguyen (2010) emphasizes that L. guttata is easy to breed, when given a broad diet, and that breeding is economically profitable for poor as well as for richer people. This activity corresponds to the profile of many farmers, which explains the high number of professions of the farmers. Lizard farming is also well adapted to older individuals as it requires little physical effort and time. We encountered all ages and professions among the farmers. Indeed, most farming is a side activity in which all generations of a family can participate. Very few problems related to the farms were mentioned. Cannibalism seems to be the principal matter of concern for those farmers not separating juveniles and adults. The lure of fast money engenders the multiplication of the farms and the increase of their size. They all seem to promote this activity, which gives them a fast return on

investment, and prices that have continuously increased at a significant rate. The comparison of reported annual income coming from lizard farming and from primary professions confirms that farming is quite profitable, especially for a side activity. Four farmers told us they wanted to further develop their farm, but were limited due to insufficient money. In doing so they pointed out the extremely high level of prices of founder lizards at the moment. Some farmers run into debt, as they are convinced of this activity as providing real financial security. For example, if they do not have enough money to buy rice, selling one male L. guttata may be enough. Others admit that they were paying water and electricity on credit until they owned a lizard farm, which allowed them to pay their debt and settle their expenses in cash. The prices are increasing so much that some clients who were offering lizards as a gift previously are now offering squid or fish instead. Lizard farming is also likely to be further developed, given that the government wants to spread the activity as a strategy to adapt to desertification and as a source of economic development for the province (Bac Binh People's Committee, unpubl. report). Vietnam has been affected greatly by desertification and has established strategies to fight and adapt to it, with Binh Thuan Province being one of the priority zones (UNCCD 2002). The progressing drought is more pronounced in northern districts of the province including our area of focus, Bac Binh. Desertification has seriously affected the livelihood of local people, yet people and policy makers of the province have gradually adapted to this problem. The prevailing strategy for farmers in Binh Thuan to respond to these changes is to plant more drought-resistant crops in non-irrigated areas and to relocate water dependent crops to irrigated land (Pham et al., unpubl. report). Lizard farming can be accomplished on poor and dry soils and is considered as a good solution to low crop yield in these areas. Leiolepis guttata is thought to rapidly adapt to increasing temperatures and

appears not to need good soil properties (Nguyen 2010). Among the 244 registered farms, 217 are located in the five non-irrigated sandy communes of the district, which is consistent with the general strategy. Besides being as an adaptation strategy, lizard farming is considered by local authorities as an important mean to diminish poverty by increasing the income of the villagers (Nguyen 2010). Almost 60% of the people in Bac Binh depend for their income on agriculture, husbandry, and fishing. This is the reason why small scale farming is considered as the main pathway out of poverty in this province (Pham et al., unpubl. report). As observed in the increase in numbers and the area occupied by lizard farms in the district, local authorities aim to increase it almost threefold by 2015. They promote it as a profitable activity in newspapers (Bao Binh Thuan. 2008. Getting rich through lizard farming in Khu Lê. Binh Thuan Online. Available from http://www.baobinhthuan.com.vn/vn/ [Accessed 4 July 2012]; Story of Binh Thuan's outstanding young farmers. 2011. Binh Thuan Online. op.cit.) and state that it has helped decrease unemployment and poverty in the province since 2004. They also suggest that local banks should grant credit terms to farmers willing to begin a new lizard farm. Moreover, ideas such as structuring the trade by initiating a meat processing enterprise or a founder stock reference center have been vaguely evoked by the district People's Committee (Bac Binh People's Committee, unpubl. report).

Risks of lizard farming.—As most of the trade and demand concern the founder stock, the current trade model seems unsustainable. Selling of founders dramatically increases competition. The risk is that the demand for founders will decrease over coming years as new farms will saturate the market, resulting in decreased demand and decreased prices. This could deeply affect families who have invested in new farms and potentially abandoned less profitable but more sustainable activities. The spatial extent

of the trade is important to consider as it may spread to new provinces. Seven farmers stated that they were selling their lizards to people from other provinces, sometimes from far away. The time needed for the supply to exceed the demand could be delayed if the activity reaches other provinces thereby increasing the demand for founders. Until now, nine other provinces are known to breed L. guttata. Most of them correspond to the range of L. guttata, except some around Ho Chi Minh City. The close proximity of the province to Ho Chi Minh City with good transport facilities by road and by sea improves possibilities to extend the activity. Indeed, the most important transportation networks are routes through Vietnam taking Road 1A, which crosses the entire province. These recent changes point to several threats for this species.

Threats to wild populations.—In the face of such development, the number of hunters is likely to increase, alongside the potential threat on L. guttata wild populations. Indeed, although the proportion of hunter-sourced animals is decreasing, the general demand increases and prices for lizards from farmers become more expensive, thereby encouraging hunting activities. Most of the farmers understand that their trade results in the decline of wild populations; they admit a decrease in availability of the species in its natural habitat and their quantitative testimonies confirm it. Although these results certainly depend on the methods used and the location, they may be taken as anecdotal evidence of wild population declines. Besides extirpation through overcollecting, the natural habitat of L. guttata is undergoing destruction and fragmentation. With this district being in full economical and tourist development, anthropogenic pressure is high and likely to further increase. Binh Thuan has recently developed its tourist industry; its remarkable sand dunes and beaches attract over two million visitors every year, and resorts in Binh Thuan represent 70% of total resorts in Vietnam (Vietnam Chamber of Commerce and Industry News. hunting of L. guttata has increased, which has 2012. A destination of waves and sand. Available from http://vccinews.com/ [accessed 14 March 2012]). Large infrastructure related to this development considerably affects the natural habitat of the lizard. Moreover, activities such as aquaculture, titanium mining, and port development compete with tourism expansion along the coastline. Emergence of new drought and stress resistant crops, which often grow better on the poor, sandy soils that form the natural habitat of this species, may exacerbate the pressure even further. Trade development, harvesting, habitat destruction, and fragmentation strongly suggest that natural populations of L. guttata might be threatened. A former president of the Hoa Thang commune stated that he wanted to impose regulations on L. guttata harvesting to stop the decline of wild populations (Huynh Ngoc Loan, pers. comm.). According to him, government members once came to Binh Thuan province and, noticing the high number of lizards in farms, decided that wild population depletion was not a problem. The abundant availability of farmed wildlife is often regarded as reducing the incentive to protect wild resources (Thomson 2008). It has been suggested that investment in the conservation of wild species is not needed when farmed substitutes are readily available (Bulte and Damania 2005). Wildlife farming has received growing attention in recent years as a way to contribute to the conservation of wild stock, but it remains one of the most controversial activities involving wildlife (Thomson 2008). Farming could actually be detrimental to species in peril instead of benefiting them (Mockrin et al. unpub. report; WCS 2008). Such patterns of wild population depletion linked to farming have been observed for species such as Siamese Crocodiles (Crocodylus siamensis) and Sika Deer (Cervus nippon) in Vietnam (Polet et al. 2002; Mockrin et al., unpubl report). Leiolepis guttata farming began as a response to the harvest of wild populations being unable to meet a growing demand. It is widely claimed in the province that farming is necessary for the species because

depleted the native population (Nguyen 2010; Bac Binh People's Committee, unpubl. report). We think, however, that the very high density of farms might be an obstacle for any beneficial impacts of the farming activity, considering the risks of disease, inbreeding, and loss of genetic diversity. Wildlife farming is thought to have a depressing effect on prices for wildlife goods, which can decrease commercial demand for specimens of wild origin, consequently reducing hunting pressure on wild populations (Bulte and Damania 2005). In our case farm development and popularity intensified the demand for founders and the prices of wild lizards consequently increased. Both wild and farmed stock prices have increased over the last few years. Wildlife farming could be considered as an alternative to hunting if it supplies a cheaper product that is able to satisfy consumer demand (Bulte and Damania 2005; Brooks et al. 2010). However, wild stock remains significantly cheaper than farmed ones, which is often a reason for sourcing lizards from the wild even when farmed substitutes are available (Ojasti 1997). One interviewee stated that the current trend in the district was an increase in L. guttata hunting due to the increasing demand. The majority of the farmers stated that their initial founder populations were either wild animals or a combination of wild and farmed stock. However, the most common manner to acquire animals is to buy the totality of founders from other farms and this tendency increased sharply over the last years. This is associated with the larger available quantities from farmers, and to the fact that previously farmed lizards are easier to rear. Increasing prices and demand are, however, likely to further encourage hunting activities. Wildlife farms could, in some cases, help restock depleted populations in the wild by providing specimens for species reintroduction or by establishing reservoirs of genetic diversity (Alvarez 2001; Thomson 2008). The proportion of successful amphibian and reptile translocation projects has increased over time (Germano and

Bishop 2009). Leiolepis guttata could be a good candidate for captive-release programs because of the lack of parental care and the ability to retain behavioral and physiological traits in captivity, traits typical of reptiles (Germano and Bishop 2009). However, for this to be feasible, a better understanding of the ecology and biology of this species is needed. Moreover, knowledge derived from the study of wild populations should be applied to farms to reproduce normal behavior in a captive environment (Gonzalez et al. 1999). The transmission of diseases and potential inbreeding depression are important risks when translocating animals or even in the case of captive escapes. The lizards are bred in high-density captive conditions and experience increased stress. The overpopulation and the promiscuity could allow rapid amplification of any diseases, which could potentially spread to wild populations of the same or other species in surrounding areas, as well as to livestock and humans (Mockrin et al., unpubl. report; Thomson 2008). Intensive animal husbandry has led to sicknesses such as avian flu (Leibler et al. 2009). Until now, no disease has been reported by L. guttata farmers. However, we noted the presence of gastrointestinal parasites (Cestoda, Cyclophyllidea) in many farmed lizards (33/56 stomach contents, 58.9%), while none were observed in wild lizards (0/10 stomach contents). Genetic management is also a major issue in captive breeding (Alvarez 2001) to minimize inbreeding and loss of genetic diversity, to minimize genetic adaptation to the captive environment, and to avoid the fixation of new deleterious mutations, as well as to maximize the success of reintroduction programs (Frankham 1995). Occasional translocations of individuals among farms could alleviate deleterious inbreeding. Efforts are needed to ensure that captive individuals will not be able to escape and will not be reintroduced without meticulous genetic studies. Genetic mixing with wild populations of the same species can potentially pass deleterious genetic traits to wild animals, generating the potential for loss of genetic integrity amongst wild popula-

tions (Mockrin et al., unpubl. report). This study demonstrates that L. guttata farming is a recent and growing activity. The demand for this lizard has continuously increased over the past years, alongside an increase of the scale of commercial farming. The retail price increased rapidly making the product a luxury and delicacy. Moreover, it is an easy farming activity to set up and to manage, with a quick return on investment. Besides the strong development of the activity in the Bac Binh District, new farms have been created in other provinces further away. About half of interviewed farmers had acquired at least part of their founders from wild-caught animals. Although the vast majority of people admit to a decreased numbers in wild populations, there is currently no quantitative evidence of this, nor any incentive to slow the depletion of wild populations. It is likely that anthropogenic pressure on wild populations will continue through habitat destruction and harvesting, which, without serious disincentives for the hunters, will probably last as long as populations are not so depleted as to become unprofitable to the hunters (Mockrin et al., unpubl. report). These results highlight the necessity to assess the current state of natural populations and the impact of hunting, to be able to establish management solutions. Research should be conducted on the biology and ecology of the species, as well as on current hunting efforts to assess the impacts of the trade on wild populations. This would also provide a better understanding of the conservation issues raised by wildlife farms and would help better manage the farms by selecting appropriate food. Additionally, this would improve the growth of the lizards, mitigate potential disease risks, and would help in designing farms more similar to the natural environment of this species. Based on this information, regulations on farming and restrictions on hunting could be implemented. This should, however, take into account the magnitude of illegal trade in Vietnam and difficulties encountered by the country to implement regulations.

Acknowledgements.--We thank Anthony Her-

rel for his precious advice and Raoul Vandamme and Yves Brostaux for their support. We thank members of BESLPO bilateral Belgian - Vietnamese project Impact of global climate change and desertification on the environment and society in Southern Centre of Vietnam (case study in Binh Thuan Province) for sharing their research results with us. We thank all L. guttata farmers and restaurateurs for their patience and time for answering our questions and for sharing their general knowledge. We finally thank the Interuniversity Council of the French Community of Belgium-University Commission for Development, as well as Binh Thuan People's Committee, Project 100, who provided funding for this research.

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TABLE A1. Questionnaire : Socio-economic Survey of Lizard (Leiolepis guttata) Farms. Survey

Date of the survey : Name of the interviewer : Name of the farmer : Address of the farm : 1. Establishing the farm • Year : • Lizards introduced when establishing the farm : Males (N) Females (N) Juveniles (N) Mixt Price bought from farmer Bought from hunter Captured from wild No. of lizards/kg bought: *where bought: Do you continue to buy/capture lizards? If yes: *what quantity? *to whome? *why? If there is capture from the wild : *Have you noticed a decrease in the number of lizards in the wild? *How often do you go hunting in the wild? *Do you select the lizards that you keep? Price of building the fence: The property : *is it yours? *how much did you pay for it/do you rent it? *do you pay for it by yourself? *did you ask for a loan to pay for it? 2. Selling lizards • Do you currently sell lizards? • If so, when did you start? • What is the minimum size at which you sell them? Males : Females : • Do you sell more males or females? • Do you sell more meat lizards or more founders? Why?

continued on next page

TABLE A2. continued from Table A1.

- Regarding founders, in which proportion do you sell males and females?
- At what price do you sell them? (males, females, immature lizards)
- What is the change in price since you have begun selling them? Year by year for each category.
- Do you sell them to :
- -friends?
- traders?
- farmers?
- restaurants?
- -If restaurants, which clients?

• Where do they come from? Do they come to buy the lizards or do you transport them there?

• Are they regular clients?

• Is demand high? At which period of the year is demand the highest?

• Do you sell all year long?

• Is there a period of the year when you do not have enough lizards to meet the demand?

• What is your annual income linked to lizard farming?

3. Miscellaneous • Who is in charge of the farm?

• Do you pay someone to take care of the farm? If so, how much do you pay?

• How much does it cost to feed the lizards?

• Do you produce food for the lizards?

• Do you have any other professional activity to supplement your income? Other crops? Animals?

• How much money do you earn from those activities?

<u>4. Additional information:</u>

TABLE A3. Survey on the Commercialization of Lizards in Restaurants (Leiolepis guttata)

Survey n°	
Name of the restaurant :	
Address :	
-How long have you been selling lizards?	
-Where do you buy lizards?	
- Farmers or traders ?	
-Where do they come from (village + distance) ?	
-Do you always buy from the same person?	
—If so, is there a contract signed ?	
—What are the conditions of this contract ?	
-Do you go buy the lizards or do they bring them to	
your restaurant ?	
—How are they transported?	
-How often do you buy lizards?	
—What quantity?	
-Do you buy more males or females?	
In which proportion ?	
— In which proportion :	
-Is there a period of the year when you do not have	
enough lizards to meet the demand of the customers?	
- At which period of the year is demand the highest?	
-Buying : At what price do you buy the lizards (per	
kg)?	
What is the change in price since you have been	
selling lizards ?	
-2010 :	2007 :
-2009 :	2006 :
-2008 :	2005 :
-What quantity do you buy each month (kg)?	
-Selling :	
—At which price do you sell them ?	

-Which proportion of the total income of the restaurant is generated by the lizards ?

-Who are the clients ? Vietnamese ? Foreigners ? Wealthy persons ?

-Which dishes on the menu include lizards? What is the price of each dish?