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Income Diversification trough Animal Husbandry for Smallholder Vanilla Farmers in Madagascar

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Abstract

The SAVA region in northeastern Madagascar is the largest vanilla producing area globally. Here, we investigated the role of animal husbandry (AH) for income diversification of small-scale vanilla farmers. To do this, 300 household heads were interviewed about livestock ownership, management and marketing. This information was complemented by data from 1800 households (HHs) on involvement in vanilla production (VP) and AH. Throughout the region, 83 % of HHs produced vanilla and 84 % kept livestock. Chicken-keeping (72 %) was most prominent, followed by keeping zebus (42 %), ducks (22 %) and pigs (13 %). A moderate correlation existed between VP and AH in general (r=0.356; $p < 0.01$) and between VP and chicken-keeping (r=0.324; $p < 0.05$), but none between VP and zebu or pig-keeping. Buying, fattening and reselling one zebu cattle yielded a price span of 9 % relative to the purchasing price, while a plus of 275 % was achieved for purchasing, fattening and reselling a pig. For chicken and ducks, the respective increase in monetary value amounted to 33 % and 49 %. Relating these price spans to the total annual income of a vanilla-producing HH revealed a potential income contribution of AH of up to 18.4 % in case of selling offspring from own cattle and 5 % or less for selling a pig or a chicken. Against the current high vanilla prices, small-scale AH is therefore an only moderately effective income diversification strategy for vanilla farmers in the SAVA region but might contribute to food security. However, in situations of low to intermediate vanilla prices AH most likely plays a more important role and might increase vanilla farmers´ resilience to income shocks.

Keywords: livelihood diversification, gross margin, pigs, poultry, vanilla production, zebu cattle

1 Introduction

For decades Madagascar has been the most important vanilla-exporting country worldwide, producing more than 60 % of the internationally traded bourbon vanilla, most of it stemming from the northeastern (NE) SAVA region (Symrise, 2019). Vanilla (*Vanilla planifolia* Jacks. ex Andrews) cultivation mainly takes place in areas experiencing a tropical rainforest climate (MAEP MG, 2003). In Madagascar´s NE SAVA region about 87 % of the rural households (HHs) are presently involved in this non-mechanized and labour-intensive activity (Hänke *et al*., 2018).

After the liberalisation of the Malagasy vanilla market in the mid-1990s, farm gate prices for green and fermented black vanilla became highly volatile (Cadot *et al*., 2009) and reached a first peak during 2000 to 2003 (Fig. 1). This peak was followed by a ten-year low vanilla price phase (15-50 \$ kg^{-1} of black vanilla), but in 2017 black vanilla prices rose to ≥ 500 \$ kg^{-1} on the world market (Fig. 1). Reasons for this steep price increase were the high market demand for natural vanilla and a partial destruction of coastal vanilla plantations through the cyclone *Enawo* in March 2017 (Financial Times, 2017a). Such strong and swift fluctuations in vanilla prices make vanilla production a promising but risky endeavour (International Trade Center, 2016).

About 80 % of Madagascar's citizens are considered extremely poor with less than US-\$ 1.90 available per person and day (World Bank, 2017). Still, agricultural revenues in the SAVA region are amongst the highest in Madagascar: in 2016 they were estimated at 572 € per person and year

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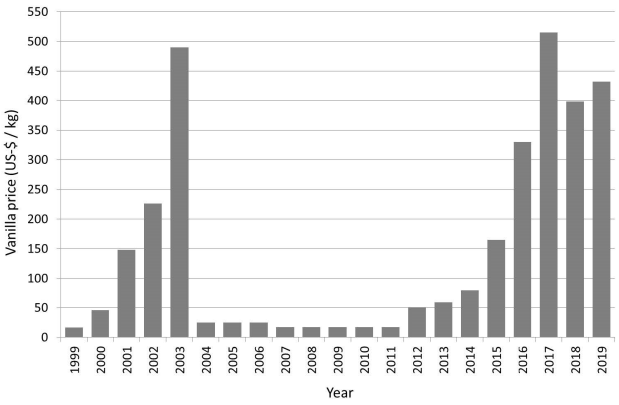

Fig. 1: *Average global prices for black vanilla during 1999 to 2019. Source: https://www.cooksvanilla.com/vanilla-market-report-a-spaghetti-western-september-2019/*

(Uruena, unpublished[1]) as compared to the national average per capita income of around 350 € in 2016 (BMZ, 2017).

However, if the current high vanilla prices would decrease substantially or collapse, HHs relying only on vanilla for their livelihood would be severely affected. In the past vanilla prices went often down so that poverty and livelihood impoverishment were widespread among vanilla farmers in Madagascar (Packer, 2008; Brownell, 2011). The most recent surveys from the region show that – despite the presently high vanilla prices – the average Malagasy vanilla farmer is multidimensionally poor (Hänke *et al*., 2018) and well below the extreme poverty line of US-$ 1.90 per person per day (Hänke & Fairtrade International, 2019), even though both studies report livelihood improvements among the local farming population. However, high vanilla prices also brought crime (Neimark *et al*., 2019) and inflation, that is, high living costs into the SAVA region (Hänke & Fairtrade International, 2019; Llopis *et al*., 2020).

As a general rule, HHs vulnerable to poverty should build resilience to income shocks, whereby income diversification is discussed as a key strategy (Ellis, 1998; Barrett *et al*., 2001), also in Madagascar (Neudert *et al*., 2015). Similarly, it has been empirically demonstrated that livestock plays a crucial insurance function in other parts of Madagascar particularly when staple crops fail (Hänke & Barkmann, 2017). Possibilities for income diversification of small-scale vanilla farmers in the SAVA region include the cultivation of the staple crop rice, and alternative cash crops such as coffee, ginger, pepper, cocoa and cloves (MAEP MG, 2003; Hänke & Fairtrade International, 2019). Likewise, there is evidence that earning off-farm income can be a key livelihood strategy to cope with climate-related shocks, particularly for the rural poor (Asfaw *et al*., 2019). However, at present the livelihood diversification of Madagascar's vanilla farmers is insufficient, both regarding agricultural diversification and off-farm-income (Hänke *et al*., 2018, Hänke & Fairtrade International, 2019), making them vulnerable to price fluctuations and income shocks.

To explore further alternatives for sustaining and diversifying agricultural incomes in the SAVA region, the present study analysed the current income contribution of animal husbandry, which is largely practiced by the rural population (Hänke *et al*., 2018) and supplies food, draught power and cash from animal and product sales (Khoabane & Black, 2009). According to Cadot *et al*. (2009), animal husbandry contributed approximately 6 % and 22 % of the annual income of vanilla-producing and non-vanilla-producing HHs, respectively, during the period 1993 to 2001, a mid-vanilla-price phase (DRAE, 2018). Since there is a complete lack of information about the current links between animal husbandry and vanilla production and its direct and indirect contributions to rural HHs' livelihoods, this study aimed at characterizing livestock production and its contribution to household income in the vanilla-cultivating SAVA region. The economic potential of animal husbandry with changing vanilla prices was determined by simulation calculations.

2 Materials and methods

2.1 Study area region

The present study was part of the inter- and transdisciplinary research project "Diversity turn in land use science: The importance of social diversity for sustainable land use innovations using the example of vanilla farming in Madagascar" (https://www.uni-goettingen.de/en/529181.html), which analyses environmental and (socio-)economic conditions of vanilla farming, and socio-political actors and institutions that are shaping rural land uses in the SAVA region of Madagascar, taking a diversity-sensitive perspective.

The SAVA region consists of four districts (MAEP MG, 2003; Fig. 2) and its name is an abbreviation of their names (Sambava, Antalaha, Vohémar and Andapa). The four districts differ with respect to topography and climate, which are shaping different agricultural production systems; also different ethnical groups dominate the districts (MAEP MG, 2003). Sambava and Antalaha are bordering the sea and have a littoral zone of 8 to 15 km width. According to the Köppen-Geiger climate classification system the climate is

[1] In 2019 agricultural income was estimated at 538 € per person and year (Hänke & Fairtrade International, 2019). However, we use the unpublished data from Uruena, since the estimation covers the same year as the present study (2017). Yet, the income estimations from 2016 and 2019 are roughly in line with each other.

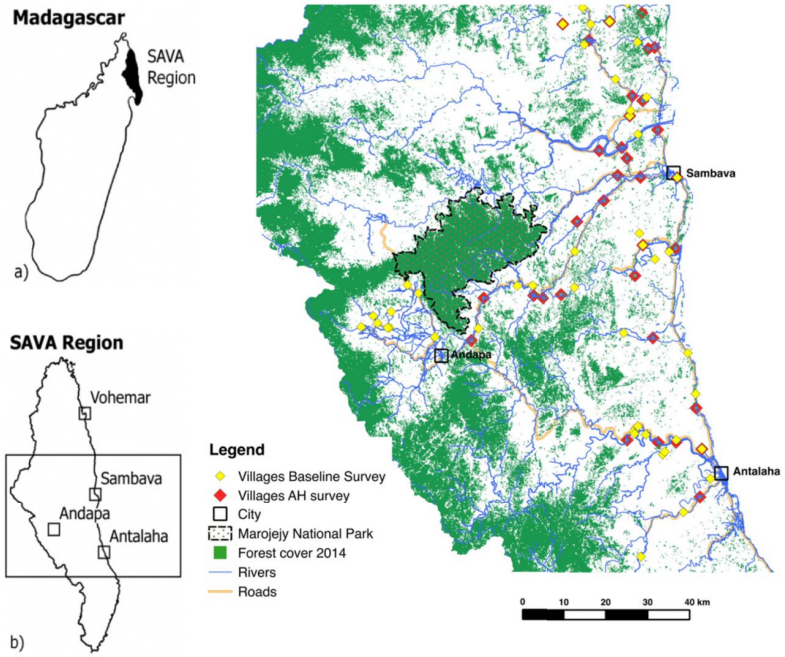

Fig. 2: *Map of the study area, with the 60 villages where the baseline survey was conducted (yellow diamonds) and the 30 villages of the animal husbandry survey (red diamonds, subset of baseline survey villages).*

classified as Af (tropical rainforest climate), with an average annual temperature of 24.7 °C and a total of 1760 mm of rain falling throughout the year (Climate Data, https://en.climate-data.org/africa/madagascar-177/). This enables the production of perennial cash crops such as vanilla. Tropical rainforest climate also prevails in the rather mountainous inland district of *Andapa*, but with slightly cooler average annual temperatures (24.1 °C) and extremely high rainfall (2753 mm yr^{-1}). This district harbours the fertile valley of *Ankaibe* which is one of the most important rice production areas of Madagascar (Jay & Giovannetti, 2013). Tropical monsoon climate (Am) with an unimodal rainy season (25.4 °C average annual temperature, 1383 mm annual rainfall; Climate Data, 2018) characterizes the Vohémar district. Cultivation of vanilla and coffee is only possible in the southern part of this district of which 25 % is covered by vast grazing grounds and utilised for extensive production of zebu cattle (Wood-Sichra, 2015). Likewise, a different ethnical group dominates the northern Vohémar district (MAEP MG, 2003).

2.2 *Data acquisition*

The study focused on the core vanilla cultivation area in the SAVA region also referred to as the 'vanilla triangle' (Fig. 2). For logistic reasons, the study villages (n=60) were located at maximum 10 km away from primary, secondary or tertiary roads; in all of them vanilla was produced and contract farming arrangements between vanilla farmers and vanilla buyers were found in 2016, commonly including sustainability standards such as Fairtrade, Rainforest Alliance or Organic (Hänke *et al*., 2018). Comparing our pre-survey data (Hänke *et al*., 2018) to official data (CREAM, 2014) and election lists we received, we can roughly estimate that 10-20 % of the regional population was excluded that way.

In the Diversity Turn Baseline Survey (DTBS), 1800 HHs (30 per village) were interviewed face-to-face on a number of social, economic and agricultural parameters (Hänke *et al*., 2018). For the purpose of the present study, only information on district and village, HH head identity, HH size, vanilla production (yes/no), livestock production (yes/no) and the keeping of animals (species and numbers) were extracted from the DTBS.

For the AH study, a subset of 30 villages was chosen so that all regions covered by the 60 villages were also represented in the subsample (Fig. 2). On the condition that a HH kept at least three large animals (zebus, pigs) or five small animals (poultry), which applied to 65 % of all HHs covered by the DTBS, 10 HHs per village were selected from name lists established in the DTBS by using the "random" function in Excel.

Between May to July 2017 data was collected in structured face-to-face interviews of 300 animal-keeping HHs. Prior to the interview, the HH head was informed about the study purpose and the interview was only conducted upon her/his oral consent to participate. The conversation was

held in Malagasy language and a translator supported the interview. Through the use of tablets, answers were directly entered into a pre-tested electronic database equipped with the opensource software 'KoboCollect' (kobotoolbox.org). An interview lasted approximately 20 minutes and addressed social aspects (gender, number and age of people engaged in AH, years of experience in AH, daily time allocated to livestock activities, training in AH), technical issues (species-specific herd sizes, purposes of animal keeping, breeding, feeding, housing and manure management, health care, animal losses) and financial aspects (purchasing price of live animals, number of animals bought, selling price of live animals, selling price of animal products, costs of veterinary care), whereby all quantitative questions covered a 12-month period retrospectively. All questions addressed the entire HH, consequently no intra-HH differentiation, such as between genders, was possible. Also, we did not collect detailed income data for other agricultural activities nor off-farm income.

The difference between the (potential) purchasing and selling price of an animal was defined as the attainable price span, and was expressed both in absolute terms and as a percentage of the purchasing price and the average annual income of a HH, that is, the revenue share of AH. However, in order to compare revenue shares of AH to income from vanilla, we used three different vanilla price scenarios. We used farmgate prices of green vanilla during a high price year (2016, 40 €), an intermediate price year (2015, 16 €) and a low price year (2011, 5 €, see Table 3)[2]. For all three scenarios we assumed an annual green vanilla harvest of 47 kg per HH, which was the average harvest in 2015-2019 (Hänke *et al.*, 2018, Hänke & Fairtrade International, 2019).

Some AH related revenues and costs were either not relevant or could not be sampled, such as opportunity costs for family labour, in-kind income or feeding costs. Either respondents could not recall the necessary information or such costs did not exist, e.g. for feeding. Likewise, income generated through sale of milk and dairy products of zebus was difficult to estimate for respondents as it either did not exist or was hardly developed in the area. In fact, only living animals were sold by most respondents. Still, we incorporated veterinary costs into an attempt to calculate gross margins (see Table 2), because most of the respondents made use of veterinary services at least once in a year.

The conversion of Malagasy Ariary (Ar) into Euro (€) was based on the average exchange rate during the study period (May – July 2017) of 3420 Ar : 1 € (own records). All monetary values were rounded to 100 Ar and 0.10 €, respectively.

[2]This estimation is based on DRAE (2018): 5-6 kg of green vanilla are needed to produce 1 kg of black vanilla.

2.3 Data analysis

Descriptive statistics were computed in Microsoft Excel® by calculating frequencies for binary and ordinary scaled variables and arithmetic mean, standard deviation (SD) and median (Mdn) for continuous variables. For monetary values only the median is reported. In case of outliers (e.g. very large herd sizes), the upper 5 % of the values obtained for a specific variable were ignored. In a second step, the residuals of continuous variables were checked for normal distribution (Shapiro-Wilk test) and homogeneity of variances (Levene's test). Since all variables were found to be distributed non-normally, differences between administrative districts (DTBS) were explored using the non-parametric Kruskal-Wallis test for continuous variables. If differences were found, pairwise comparisons with Bonferroni correction were computed. Two-sided Pearson correlation analysis was used to test for correlations between VP and AH. Significance was declared at $P < 0.05$. All statistical analyses were computed with SPSS 24.0 for Windows (IBM Corp., Armonk, NY, USA).

3 Results

3.1 Animal husbandry and vanilla production at district level

The DTBS showed that 83 % (SD 19.1) of the surveyed 1800 HHs produced vanilla and 84 % (SD 8.8) kept livestock; of these 77.3 % kept at least three large or five small animals. Among the animal keepers, 42 % (SD 15.8) had zebu cattle, 13 % (SD 9.8) kept pigs, 72 % (SD 11.1) kept chicken, and 23 % (SD 10.4) reared Mallard and Muscovy ducks (Fig. 3). Involvement in AH and VP was common in all four districts, but frequency of HHs engaged in VP differed significantly between Sambava (92.4 %) and Andapa (70.6 %, $P < 0.05$). A difference at the district level was also found for pig-keeping, with a significantly higher frequency in Andapa (18.4 %) than in Antalaha (7.6 %; $P < 0.05$).

Across the 60 DTBS villages, a moderate correlation (Pearson) existed between VP and AH, between VP and chicken-keeping, and between VP and duck-keeping (Table 1). No correlation was found between VP and the keeping of zebus or pigs, however.

Table 1: *Results of Pearson correlation analysis between vanilla production (VP, % of households per village) and keeping of different animal species (% of households per village) across 60 baseline study villages in the SAVA region.*

		Households (%) involved in				
Parameter		*Animal husbandry*	*Zebu keeping*	*Pig keeping*	*Chicken keeping*	*Duck keeping*
Correlation (r) with VP		0.356	0.140	-0.044	0.328	0.331
Significance (2-sided)		0.005	0.286	0.736	0.011	0.010
95% Confidence interval	Upper value	0.152	-0.008	-0.271	0.064	0.088
	Lower value	0.571	0.292	0.171	0.592	0.539

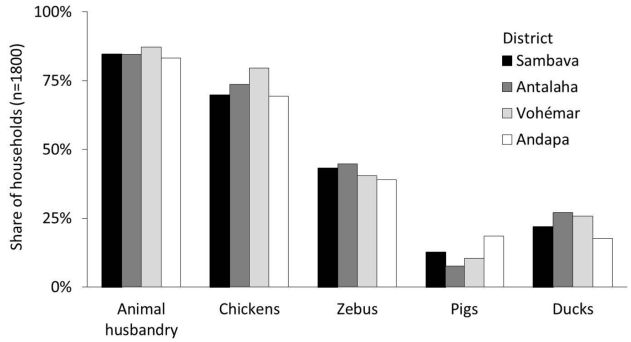

Fig. 3: *Share of households per district of the SAVA region that are engaged in animal husbandry in general, and specifically in keeping zebu cattle, chickens, pigs or ducks (DTBS data baseline study, n=1800).*

3.2 Characteristics of animal husbandry in the SAVA region

Of the 300 people interviewed in the AH survey, 33 % were female and 67 % male. In 80 % of the interviews it was the HH head who answered and 17 % thereof were female. According to the interviewees, 585 persons in total and thus 1.9 persons per HH (SD 0.7; male-female ratio 1.1 : 1.0) were engaged in AH, whereby according to the DTBS a HH comprised an average 4.7 (SD 0.6) persons, 3.3 thereof aged 18 years or older. The average age of persons involved in AH was 36 years (SD 12), while only 42 persons aged less than 18 years were involved in AH. Per day, the involved HH members invested 2.2 hours (Mdn 2.0) of labour in AH. Only eleven out of the 585 persons engaged in AH had received a formal training in this activity, mostly of short-term nature and offered by an NGO, the Ministry of Agriculture or a vanilla purchaser in cooperation with the German agency for international cooperation (GIZ). No HH received financial support for livestock-keeping activities and only five persons engaged in AH received a regular payment for this job.

Zebu cattle were kept by 52.6 % of the 300 HHs, 16.3 % kept pigs, 90.3 % kept chickens, and 41.7 % kept ducks. Zebu-keepers had 6.5 years of experience (Mdn 4.0 years) in this activity, whereby 36.7 % kept cattle for 20 years or more, and 21.5 % kept zebus for one or two years only. One fifth (20.4 %) of the pig-keepers had 10 or more years of experience in pig keeping, while 24 HHs (48.9 %) kept pigs for just one year or less. Dichotomy also prevailed among chicken-keepers, of whom 66.1 % had more than 15 years of experience whereas 24.4 % kept chicken for no longer than five years. Of the HHs keeping ducks a very high proportion (44.8 %) had just started this activity during the past 5 years.

Herd sizes per HH keeping the respective species averaged 4.9 zebus (Mdn 3.5), 3.0 pigs (Mdn 2.0), 30.2 chickens (Mdn 22.0) and 11.3 ducks (Mdn 7.0). Out of the 158 zebu-keeping HHs only six kept between 14 and 53 animals; yet, zebu herd sizes did not differ between the four districts. Among the 49 pig-keepers only three HHs kept ten or more animals, with similar average herd sizes across districts. Among the 271 chicken-keepers, only seven reared between 100 and 600 birds, and the average chicken flock size was significantly larger in Vohémar (31 birds, $P < 0.05$) than in Antalaha (22) and Sambava (22).

Only local breeds of zebu cattle, pigs and chickens were kept, an exception being five commercial chicken farms that reared white hybrid broiler strains and purchased their one-day chicks in Antananarivo. Although some farmers rented out bulls or boars for mating, clear breeding goals and strategies did not exist for any of the livestock species, and artificial insemination was not used at all.

Zebus were primarily used to cultivate land and in particular rice fields (49 % of all zebu-keeping HHs), followed by milk production for home consumption in 32 % of the zebu-keeping HHs. In the latter case, a cow was milked for 5.6 months (Mdn 3.0) after calving and yielded about 1.4 litres (SD 0.6) of consumable milk per day. Further uses of cattle were sale of live animals (25 % of zebu-keeping HHs), renting out cattle for draught power (21 %), selling of milk and meat (8 %) and leasing a breeding bull (6 %). Pig-keeping HHs stated that they mostly sold pork meat (51 % of HHs); other purposes were sale of live animals (40 %) and home consumption of meat (25 %). However, pork-selling

HHs did not explicitly mention subsistence consumption as a main purpose of pig keeping. Some pig-keepers (6 %) rented out their boar for mating – normally they received a weaned piglet in exchange. Most chicken-keeping HHs (98 %) raised birds for home consumption of meat but 40 % also sold live birds to generate cash income. Consumption and sale of eggs were rare (3 and 1 mentions, respectively), and HHs were unable to quantify the laying performance of their hens. The 125 duck-keepers were mostly interested in meat consumption (99 %), but 32 % also sold live animals and 8.8 % sold eggs, whereas home consumption of eggs was only mentioned by two respondents. Likewise, there was no reliable information on laying performance of ducks.

3.3 Livestock management practices

No feed was purchased for zebus, but some respondents mentioned that they harvested and fed cassava leaves. All HHs tethered their zebus to a tree, shrub or pole for grazing during daytime. Only three HHs fertilised their garden with zebu dung. Sixteen zebu-keeping HHs (10 %) lost at least one cattle (mean 1.3) in the past 12 months due to undefined diseases, and 13 HHs lost zebus (mean 1.2) due to accidents or storm. Altogether a mortality rate of 10 % resulted from these reports, which was contrasted by an annual calving rate of 41 % across all adult female zebus covered by the survey.

Pigs were fed with rice bran (90 % of pig-keepers), kitchen waste (71 %) and rice meal (51 %) as well as cassava tubers (45 %), bananas (20 %), maize and yam (10 % each). Only a third of HHs feeding rice bran and rice meal purchased these feedstuffs, all other HHs used own sources. Half of the pig keepers (51 %) tethered adult pigs to a tree or pole during daytime and close to the house at night; 31 % kept pigs in a stable made from wood or corrugated iron sheets. Five HHs had built a fenced and shaded pig enclosure, whereas the remaining HHs left their pigs scavenging day-round. Only 13 HHs regularly cleaned the pigs' night resting place but no HH used pig dung in gardens or fields. Due to disease – most probably African swine fever – seven pig-keepers lost a total of 59 pigs in the past 12 months, resulting in an overall mortality rate of 28 %. Adult sows had at best one litter per year with an average litter size of 5.9 piglets, yet prolificacy across all pig-keeping HHs was only 2 piglets per adult sow and year.

In 81 % of the chicken-keeping HHs birds were freely scavenging during daytime and additionally received rice or maize grain (86 % of HHs); 10 % of the HHs also offered rice bran, cassava chips and kitchen waste. Only three HHs with large flocks of commercial broiler strains purchased commercial starter and finisher feed. Most HHs (51 %) kept their chicken in a barn or a fenced area underneath the house (built on stilts); in 11, 6 and 3 HHs birds spent the night on a tree, in a cage and inside the house, respectively. Chicken houses were cleaned by 35 % of the chicken-keepers, with intervals ranging from once a day to once a year. Only 8 of these HHs used chicken manure in their rice field or garden. In 90 % of the HHs 26.6 birds (Mdn 20) were lost in the past 12 months, mainly due to Newcastle disease or avian pasteurellosis (79 % of HHs), resulting in a mortality rate of 41.2 %. Yet, 71.2 % of the chicken-keepers did not recur to prophylactic treatments and 77.5 % did not treat sick chicken. Theft was another important cause for chicken losses cited by 61.6 % of the chicken-keepers who had lost on average 12 birds (Mdn 8) in this way. Chicken losses due to storm, predation by stray dogs and road accidents were of minor relevance. Only 10 % of the chicken-keepers had not experienced bird losses during the past 12 months.

Most duck-keepers (81 %) left their birds scavenging freely; only 5.6 % provided a fenced duck yard. In addition, duck-keeping HHs fed rice and maize grains or rice bran (87.2 % in both cases), kitchen waste (46.4 %) and cassava chips (13.6 %). At night ducks were kept in a stable (88 HHs) or a fenced area underneath or near the house (41 HHs). Duck houses were cleaned by 46.4 % of the HHs at daily to yearly intervals. Only nine of these HHs applied duck manure to their rice, vanilla or vegetable field. Losses occurred in 60.8 % of the duck-keeping HHs; in more than half of the cases (33.6 %) an average of 10.5 ducks (Mdn 6) died of Newcastle disease or avian pasteurellosis. Thirty-nine duck-keepers lost an average of 11.3 birds (Mdn 5) through theft during the 12 months preceding the survey.

Animal health was a major concern of the respondents with 258 explicitly mentioning the need for improved veterinary services. In general, services solicited by respondents included treatments against endo- and exo-parasites, dosing of vitamins and unspecified vaccinations. In contrast the government does provide regular (obligatory) vaccination against bovine coronavirus and anthrax (Institut d'Elévage, 2008; Belalahy, pers. comm., 12.07.2017). Annual median health care costs of 15,000 Ar, corresponding to 4.40 €, were reported for a zebu, with a range from 1,000 to 75,000 Ar (0.30 to 23.00 €) for an average of 1.9 treatments per year. For pigs, about three treatments (vaccination, deworming) were applied per year with a median cost of 10,000 Ar (2.90 €). Only 30 chicken-keeping HHs had their birds vaccinated against Newcastle and further (undescribed) diseases (average two treatments per year), at median costs of 2,000 Ar (0.60 €) per bird.

A general need for support with AH was claimed by 158 respondents, with proposed topics ranging from aquaculture to pig production, broiler production and milk production.

Table 2: *Livestock holdings, purchasing, re-selling price and profit per animal; veterinary costs and herd values per livestock keeper, converted to Euro.*

Variable	*Zebus*	*Pigs*	*Chickens*	*Ducks*
Herd size per household keeping the respective species (Mdn)	3.5	2.0	22.0	7.0
Per animal				
Purchasing price [€ head^{-1}]	321.60	23.40	4.40	5.90
Selling price [€ head^{-1}]	350.90	87.70	5.90	8.80
Profit [€ head^{-1}] (Selling minus purchasing price)	29.20	64.30	1.50	2.90
Profit over purchasing price (in %)	9	275	33	49
Veterinary costs				
Veterinary costs per head [€ yr^{-1}]	4.40	2.90	0.60	0.60
HHs applying veterinary treatments (n)	113	33	33	14
Veterinary costs per herd [€ yr^{-1}]	15.40	5.90	12.90	4.20
Veterinary costs relative to herd value (%)	1.3	5.3	11.4	8.2
Herd value				
Financial capital bound in median-sized herd [€]	1,176.90	111.10	112.60	51.50

Median values for the SAVA region (n=300)

Table 3: *Herd value in relation to household (HH) income*, income contribution per purchased animal and offspring under different vanilla price scenarios in the SAVA region; a) High price scenario (2016), b) Intermediate price scenario (2015), c) Low price scenario (2011). Herd sizes and values are based on Table 2, all values indicate median values.*

Scenario	*Variable*	*Zebus*	*Pigs*	*Chickens*	*Ducks*
a) High price scenario (2016)†	Herd value relative to HH income (%)	62.4	5.9	6.0	2.7
	Income contribution, purchased animal (%)	1.3	3.3	0.1	0.2
	Income contribution, own offspring (%)	18.4	4.5	0.1	0.4
b) Intermediate price scenario (2015)†	Herd value relative to HH income (%)	157.0	14.8	15.0	6.9
	Income contribution, purchased animal (%)	3.9	8.6	0.2	0.4
	Income contribution, own offspring (%)	55.1	11.7	0.1	0.8
c) Low price scenario (2011)†	Herd value relative to HH income (%)	523.3	49.4	50.1	22.9
	Income contribution, purchased animal (%)	13.0	28.6	0.7	1.3
	Income contribution, own offspring (%)	183.8	39.0	0.4	2.6

* See footnote 1: The average annual income of a vanilla producing household in the reference year 2016 was 572 € per person (Uruena, unpublished) and thus 1,888 € (6,450,120 Ar) for a median HH with 3.3 income earning members.

† In 2016, average farm-gate prices of green vanilla were around 40 €/kg (Hänke et al., 2018). Average vanilla harvests changed only marginally between 2015-2019 (Hänke et al., 2018, Hänke & Fairtrade International, 2019). To reflect different price scenarios, we use an average vanilla harvest of 47 kg per HH and year, and farm-gate prices of green vanilla in a high price year (a: 2016, 40 €), an intermediate price year (b: 2015, 16 €) and a low price year (c: 2011, 5 €).

Need of financial means for improving livestock keeping with modern rearing equipment, better feeding, fencing and housing was mentioned by 119 respondents. Lack of land for housing animals and/or expanding AH was problematized by 43 respondents, 61 persons complained about animal theft and 32 respondents requested more training, education and advice in aspects concerning AH.

3.4 Livestock transactions and financial value of animals

Of the cattle-keepers 20.3 % had bought at least one zebu (Mdn 1.0) in the 12 months preceding the survey (Table 2), for a median price of 1,100,000 Ar (321.60 €), and 24.7 % of the HHs had sold a zebu for 1,200,000 Ar. Zebu milk was sold by 4.4 % of the zebu-keepers only, at 3,000 Ar per litre (0.90 €). Eight HHs marketed zebu meat at 16,000 Ar per kg (5.00 €) irrespective of the part. Amongst the pig-

keeping HHs, 41 % had bought at least one pig (Mdn 1.5) in the preceding 12 months, for a price of 80,000 Ar, and 41 % pig-keepers had also sold at least one pig for a price of 300,000 Ar. Pork meat was sold by 51 % of pig-keepers, at 10,000 Ar per kg (2.90 €). Of the small-scale chicken-keepers (flock sizes less than 100 birds) 13.3 % had bought chickens (Mdn 2.0) in the past 12 months, at 15,000 Ar per bird. Twenty-four percent of the 125 duck-keeping HHs had bought at least one duck (Mdn 4.0), either as hatchery egg, juvenile or adult bird, with prices ranging from 4,000 to 50,000 Ar and a median of 20,000 Ar (5,90 €) for a bird and 1,000 Ar (0.30 €) for an egg. Sales prices realised by poultry-keeping HHs were 20,000 Ar per chicken (40.2 % of HHs) and 30,000 Ar per duck (32.0 % of HHs). Chicken eggs were usually not sold but kept for brooding, whereas duck eggs were sold at 1,000 Ar per egg (0.30 €, 8.8 % of duck keeping HHs).

Economic benefits of AH were calculated per one animal reared on-farm or purchased and sold, and their median purchasing and selling prices, thereby accounting for the cost of veterinary care but ignoring feed and labour costs that were too heterogeneous and often negligible across the 300 survey HHs. Consequently, the price margins represent essentially the gross margin in case of purchased animals and gross income in case of animals born on farm (Table 2).

For a purchased and resold zebu the gross margin of 85,000 Ar corresponded to 9 % when expressed relative to the purchasing price. For a zebu born on farm, a gross income of 1,185,000 Ar could be realised. Zebus are mainly kept for their draft power and their value does not change much when bought or sold. Thus a herd of 3.5 animals represented a value of 4,025,000 Ar (1,176.90 €), equivalent to 62 % of the average annual income of a vanilla-producing HH, and veterinary costs for the herd of 52,500 Ar per year represent 1 % of the herd's value. Pig-keeping HHs attained a gross margin of 210,000 Ar when purchasing, fattening and reselling a pig, and a gross income of 290,000 Ar when selling own offspring, which corresponded to 3.3 % and 4.5 % of the average annual income of a vanilla-producing HH, respectively. The steep rise in the animals' value during the rearing period clearly indicates that the main purpose of pig-keeping is meat production. A herd of two pigs bound a capital of 380,000 Ar (111.10 €) corresponding to 6 % of the annual income of a vanilla-producing HH, whereas annual veterinary costs of 20,000 Ar for the herd consumed 5 % of its value. A median-sized herd of 22 chickens held a capital of 350,000 Ar, and a gross margin of 3,000 Ar was achieved for a bought and resold chicken, while 18,000 Ar could be obtained when the bird hatched on the farm. Ducks were often raised from hatching eggs bought at 1,000 Ar (0.30 €). The median flock size of 7 ducks held a value of 175,000 Ar (51.50 €) and a gross margin of 10,000 Ar was realised for selling a purchased duck, while for a duck hatched on farm a gross income of 29,000 Ar was achieved.

4 Discussion

In the SAVA region, AH is practiced by a vast majority of the population (84 %) and consists foremost of keeping zebus, pigs, chickens and ducks. However, the degree of professionalisation is low. The latest available report on AH in the SAVA region (MAEP MG, 2003) stated that the highest share of HHs was engaged in zebu-keeping, followed by keeping poultry and pigs (MAEP MG, 2003). In the year 2017 there were about twice as many HHs engaged in chicken-keeping as compared to zebu-keeping, but it was impossible to infer the reasons that might have led to the declining importance of zebus in the 15 years that elapsed since the release of the governmental report.

According to the 300 respondents involved in the AH survey, an average of 2.6 zebus, 0.5 pigs, 19.9 chickens and 4.7 ducks were kept per HH in 2017, with many HHs keeping few animals of several species and only very few HHs keeping many animals of one species. Especially the obtained zebu herd sizes differed greatly from those in other regions of Madagascar; e.g., in the south-western Mahafaly region zebu herd sizes range between 17 and 25 heads (Neudert *et al*., 2015). Even though in the Mahafaly region, only 61 % of the rural HHs practiced AH, namely poultry-keeping (61 %) and zebu-keeping (48 %), AH ensured higher wealth status and household resilience as compared to HHs not involved in AH (Neudert *et al*., 2015; Hänke & Barkmann, 2017).

For pigs as well as for chickens in the SAVA region, an average flock size of 9 animals per HH was reported 15 years ago (MAEP MG, 2003); while pig herd sizes have decreased substantially, chicken flock sizes have doubled until 2017. Yet if only the number of adult birds recorded in 2017 is accounted for (2620 out of 8178 chickens) an average of 8.8 birds per HH is calculated, which would be in line with the previously reported numbers.

Correlation analysis indicated that VP relates moderately, but positively, with AH in general, and in particular with rearing chickens and ducks. Yet, duck-keeping was only practiced by 42 % of the surveyed HHs as opposed to 90 % keeping chickens. In view of the fact that purchasing prices for adult ducks are higher than for chickens, a higher income of HHs engaged in VP might positively influence duck-keeping. Furthermore, the fact that many of the interviewed duck-keepers have started this activity not more than five years ago might point to a certain investment of vanilla

money into duck-keeping and support a causal rather than coincidental relationship with VP. The assumption that financial gains from VP might be invested in purchasing cattle or pigs is not supported by the results of the correlation analysis, despite the high percentage of HHs who took up these activities less than five years ago. The notion is supported by the data of Andapa where the lowest share of HHs is engaged in VP and the highest in pig-keeping. This can be explained by the importance of rice cultivation in this district (MAEP MG, 2003; Hänke *et al*., 2018), whereby cattle are needed for draught power and pigs can be fed with valuable crop residues such as rice bran and broken rice grain, whereas rice straw can be utilised to feed cattle. Also, the Andapa district is far hillier and harbours many valleys which are suitable for agriculture, particularly paddy rice production (Laney & Turner, 2015; Hänke *et al*., 2018).

Beyond their provision of workforce, in Madagascar zebu cattle are kept as capital stocks and for insurance reasons (Cellule de Prévention et Gestion des Urgences, 2012; Hänke & Barkmann, 2017). They also have a high sociocultural value and are often used for religious holidays and festivities (MAEP MG, 2003; Acquier, 2014; Wüstefeld, 2004). Zebu husbandry in Madagascar is characterized by lower disease rates than on the African continent from where it is isolated (Suttie *et al*., 2005). Still, the Malagasy Ministry for Agriculture reported a loss of 30 % of the zebu stock between 1970 and 2000 due to diseases, cyclones and flooding (MAEP MG, 2003). A zebu mortality of 10.2 % was calculated across the surveyed HHs, which reduces to 8.8 % when only considering deaths due to diseases. This value corresponds closely to the mortality rate of 8 % reported for extensive zebu husbandry systems in entire Madagascar (Rasambainarivo & Razafindratsita, 1987; as cited in Feldt *et al*., 2016).

With more than 300 €, the purchasing and sale prices of zebus were nearly five times higher than in southwestern Madagascar (Feldt *et al*., 2016). Reasons for this divergence may be the higher income level in the SAVA region, high levels of inflation due to the vanilla boom (Hänke & Fairtrade International, 2019; Llopis *et al*., 2020) as well as larger herd sizes per HH in the Mahafaly region (Feldt *et al*., 2016). Also, the SAVA region is largely isolated and road connectivity to other parts in Madagascar is weak, which makes many imported goods more expensive. In a key-informant interview, the director of the regional office for agriculture and animal husbandry mentioned a substantial lack of zebu meat in the SAVA region, necessitating cattle and meat imports from the neighbouring regions of Sofia and Diana, from where zebus are often imported on the hoof. According to this informant, the deficit was brought about by a sequence of seasons of high meat prices as a consequence of the increasing vanilla prices. Since more money was available the HHs consumed more animal products and many zebu keepers in northern Vohémar sold animals and reduced their herd sizes (Belalahy, pers. comm., 12.07.2017).

For a vanilla-producing HH, on the other hand, selling of animals contributed only 6 % to the annual income in 2009 (Cadot *et al*., 2009). The present calculations are in line with this finding, with sales of one previously purchased animal contributing at best 3.3 % to the annual income of a HH engaged in VP and sale of own offspring contributing 18.4 % in case of a zebu cattle but only 4.5 % or less in the case of a pig, chicken and duck. Substantial contribution of chickens to HH income seems only possible for professional broiler production units that purchase one-day old chicks, use commercial genetics and feed, and realize a short rearing period (Alders & Pym, 2009). There were, however, only few of such farms among the 271 chicken-keepers sampled in this study. Zebus have a high monetary value and thus bind capital but yield only little profit when purchased and resold. They can, therefore, contribute only a small share to the monthly HH income, especially since also milk and beef are rarely sold by HHs in the study region. However, our analysis ignores the economic importance of the draught power provided by zebus, especially in the rice fields, which was used by 77 % of the zebu-keeping HHs covered by the DTBS. Furthermore, from the present data it cannot be deduced whether zebus provide an insurance function as in other regions of Madagascar (Fisher, 2009; Hänke & Barkmann, 2017), but since the capital bound in a median-sized zebu herd equals 62 % of the average annual income of a vanilla-producing HH, an insurance function of cattle against shocks such as cyclone damage of vanilla plantations, theft of vanilla or a sudden vanilla price decrease seems plausible. Moreover, it is difficult to compare different vanilla price scenarios and their consequences for the HHs' animal husbandry. While it is obvious that currently vanilla prices are historically high (see Fig. 1), livestock could play a much more important livelihood role when vanilla prices drop (see Table 3) – this is especially the case for pigs with potentially large litters and for poultry which can be kept in higher numbers and therefore sold on a much more regular basis than cattle, even though the income contribution of one sold zebu is substantial. On one hand, declining vanilla prices could also lead to deflation in the SAVA region, and consequently declining animal prices and/or shrinking demand for meat. On the other hand, similar to other Malagasy regions where livestock is socio-culturally often functioning as a "bank account" that can be liquidated in times of need (Wüstefeld, 2004), this aspect might play out in the study re-

gion as well. Therefore, the role of animal husbandry in low and intermediate vanilla price phases needs further research in the SAVA region.

Still, despite its currently limited income earning function, the potential of AH for a diversification of the HHs' food basket should not be ignored: especially chicken and pig meat were extensively consumed by the surveyed HHs, and own consumption of meat (and to a much lesser extent milk and eggs) was a strong reason for engagement in AH. Nevertheless, a more detailed study is needed to quantify the contribution of animal source food to the HHs' diet and has been conducted in 2019 (Andriamparany *et al*., forthcoming). However, recent NGO reports and studies show that even though a lot of cash is currently circulating, much of the regional population is malnourished; particularly protein and mineral deficits are common and diets are too strongly focused on carbohydrates, mostly from hulled rice (USAID, 2018; Golden *et al*., 2019; Hänke & Fairtrade International, 2019). A lot of locally consumed meat is currently imported from other regions of the country, and many international stakeholders and development agencies increasingly invest into livelihood diversification of vanilla farmers, also including animal husbandry (personal communication with GIZ, 2019).

As far as livestock management practices are concerned, feeding, health care, housing and manure management were inadequate across animal species. Rice bran, often mixed with rise husks, is an acceptable supplement feed for cattle but its comparatively high fibre content may pose a challenge to pigs and poultry (Heuzé & Tran, 2015). Rice and maize grains were fed as well, but most of the times animals were observed scavenging on sun-drying grain rather than receiving a substantial amount of cereal grains every day. As far as the feeding with cassava is concerned, it was unclear if the respondents referred to leaves (which was the case for cattle, but not specified in case of pigs), full tubers or cassava peels – the latter also being a rather poor feed for monogastric animals due to a high content of fibre and free cyanide (Akinola *et al*., 2013). The poor housing conditions were not only provoking accidents (strangulation) of tethered cattle and pigs and theft of poultry but were also preventing appropriate manure collection and recycling to crop land, which mirrors the situation in other parts of Madagascar where dung is also hardly applied to vegetable, cereal and tuber crops (Hanisch, 2015). The combination of inadequate feeding and scavenging, respectively, with poor housing also fosters prevalence and spread of diseases, in particular as health care is apparently neglected by the animal keepers. Pig-keepers and veterinarians pointed to African swine fever (ASF) as a major problem; despite Madagascar's insular situation, ASF made its way to the SAVA region, diminishing the pig population by half (Ravaomanana *et al*., 2010). Studies in Kenya and the Democratic Republic of Congo showed that ASF was responsible for 31 % and 98 % of pig diseases (Kagira *et al*., 2010; Kambashi *et al*., 2014). The sale of 2 kg of pork would cover the annual costs of prevention of common health problems, such as parasitoses, for a median-sized pig herd. Yet, there is no effective vaccine against the ASF virus (OIE, 2019) which makes pig production a rather risky business and might in part explain its low correlation with VP. Poultry-keeping, on the other hand, is threatened by the occurrence of the disease locally termed "kopinda", which can either be Newcastle disease or avian cholera, with a higher probability of occurrence for the former (Belalahy, pers. comm., 12.07.2017). These diseases can be responsible for 40 – 80 % of annual stock losses (Maminiaina *et al*., 2007; Borgerson *et al*., 2017), which also renders investment in poultry rather risky. Even though available and effective, costs for veterinary prevention of the mentioned chicken diseases were relatively high with 12.90 € for the median-sized flock of a chicken-keeping HH; this would require the purchase and resale of 9 chicken or sale of 2.5 chicken reared from own offspring.

5 Conclusion

The contribution of animal husbandry to income diversification in the vanilla-producing SAVA region of north-eastern Madagascar is so far limited. However, vanilla farmgate prices are currently at a historically high level, therefore other agricultural activities cannot compete with vanilla in terms of cash income at this moment. Since vanilla prices will unlikely remain as high as they are now, a professionalized animal husbandry could make an important contribution to local food security - which in parts is already the case now - and be an attractive income source if vanilla prices drop again. Thereby especially pork production but also poultry keeping bear economic potential for intensification in the SAVA region. Our insights are transferable to other rural settings in Africa where farmers focusing on cash crops with highly volatile prices such as cocoa, coffee, cotton or other spices (e.g., cloves, cinnamon, pepper) could also diversify their activities by engaging in - small-scale - market-oriented livestock production. Such a development requires substantial improvement of animal husbandry practices, particularly regarding appropriate feeding, health care and housing. In the SAVA region, the latter aspect might also reduce the threat of livestock thefts and diseases and provide options for appropriate manure recycling to cropland, which is completely lacking at present. To realize this potential,

however, local livestock keepers need financial and training support.

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Conflict of interest

Authors state they have no conflict of interests.

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