Final Project Report

Bawean Endemics Conservation Initiative (BEKI): Saving the rarest pig species on earth: population characteristics and community perceptions of the Endangered Bawean warty pig *Sus blouchi* on Bawean island, Indonesia

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Final report for the project

Saving the rarest pig species on earth:

population characteristics and community perceptions

of the Endangered Bawean warty pig *Sus blouchi* on Bawean island, Indonesia

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1. General information

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2. Summary

Bawean warty pigs (*Sus blouchi*) are endemic to the island of Bawean, a small island of approximately 190 km^2, situated in the Java Sea 120 km north of Surabaya, East Java. The species is Red-Listed as Endangered, still covered as a sub-species under Javan warty pigs (*S. verrucosus*). Threats include habitat loss and hunting for crop-protection, yet there is no legal protection by Indonesian law. Hybridisation with European wild pigs (*S. scrofa*) may pose an additional risk. Virtually nothing is known about Bawean warty pigs. This lack of ecological information hinders effective conservation planning. In this study we aimed to gather information about distribution, population size, behaviour and ecology. Additionally, we aimed to explore attitudes of local people towards warty pigs, wildlife and nature, and investigate crop-raiding and hunting. We used a combination of camera trapping, direct observations and interviews. Analysis included the Random Encounter Model (REM), that enables to estimate population sizes without the identification of individuals, Occupancy Modelling, Cultural Consensus Analysis and standard statistical tests. Our study was conducted from November 2014 to December 2015. We found that only Bawean warty pigs but no *S. scrofa* occur on Bawean. REM revealed that 172−377 Bawean warty pigs exist on Bawean, confirming the IUCN Red List status. Animals prefer community forest and areas nearer to the forest border, possibly due to a higher availability or quality of food. Maximum temperature of a day had a negative, and effort a positive significant effect on whether a video of pigs was recorded, while rainfall, minimum temperature and moon light did not have an effect. Fires were omnipresent during the end of the dry season. Mean group size was 2.1 or 4.6 individuals, depending on method, and are similar to group sizes of *S. scrofa*. Mean litter size was 2.2 (1-6), which is less than half of what is reported for *S. scrofa*, possibly giving a hint why warty pigs are outcompeted on Java. Groups included adult males in on average 11% of the videos, regardless of whether immatures were also present. Piglets were only present from March to October, with a peak in August of 65.9% of groups containing piglets. Videos were captured all throughout the 24 hour cycle, but capture times indicated crepuscular and nocturnal tendencies. Interviews revealed that pigs are perceived as serious crop-raiders and protection measures are always lethal to the animals. However, attitudes towards wildlife and nature are generally good. We conducted education activities and distributed awareness material to support our field work. Results on the Critically Endangered Bawean deer were worrying with only 38 videos as opposed to 985 videos of Bawean warty pigs, and 92% of all videos taken in a 17 hectares small area. Activity was spread over the hours of the day, with no clear pattern. Our results may be used as a basis for the planning of conservation measures for Bawean warty pig and deer, and will be distributed accordingly to forestry authorities, practitioners and IUCN specialist groups. Several scientific articles and public media have been published. We also supported local capacity building by training a large team of students, field assistants and forest guides, and cooperated closely with an Indonesian senior researcher. Finally, we recommend that the very supporting and enthusiastic staff of the protected area management is strengthened by providing appropriate resources (financial, equipment, skills).

3. Introduction

3.1 Background

The Bawean warty pig (*Sus (v.) blouchi)* is still listed as a sub-species of the Javan warty pig (*S. verrucosus*) on the IUCN Red List, however, Groves & Grubb (2011) have raised the taxon to full species level. Here, we will refer to Bawean warty pig as an own species. Both species are endemic to Indonesia, with the Bawean warty pig being endemic to the approximately 190 km^2 – large island of Bawean, located in the Java Sea 120 km north of Surabaya, East Java. An attempt to assess the separate Red List status of the Bawean warty pig by the IUCN SSC Wild Pig Specialist Group (WPSG) resulted in the status "Data Deficient", emphasising the extreme lack of knowledge about this pig species (Meijaard et al. 2014). The Bawean warty pig is one of the rarest pig species in the world, along with the Visayan warty pig (*S. cebifrons*) and the pygmy hog (*Porcula salvania*).

Sundaland is listed as a top biodiversity hotspot according to numbers of endemic species and habitat loss (Myers 2000). Southeast Asia and especially Indonesia are facing one of the highest deforestation rates (Sodhi et al. 2004). The island of Java is amongst the most populated islands in the world; it holds only 7% of the land area of Indonesia, but 67% of the human population (Lavigne & Gunnell 2006). This puts an enormous pressure on biodiversity (Miettinen et al. 2011). More than 90% percent of Java's natural vegetation has been lost, with about 7% of the natural primary or secondary coinciding with areas that are difficult to access such as mountains (Lavigne & Gunnell 2006). Following the encroachment of agricultural land into forests, pigs forage on crops, and are subsequently hunted for pest control. The situation is similar on Bawean. Javan warty pigs are believed to increasingly hybridise with Eurasian wild pig possibly due to the need to share the decreasing habitat, which puts an additional pressure on the species (Meijaard et al. 2014). It is not clear yet if European wild pigs also occur on Bawean. Warty pigs are not legally protected by the Indonesian government. Protection and conservation thus depends completely on local communities. A holistic conservation project has to take the perceptions towards the species into account, as well as the underlying political, social, religious and economic motivations of local communities.

A recent population survey including interviews and a small number of camera traps on Bawean island was conducted in October 2013 (Semiadi & Meijaard, 2013) and showed that warty pigs are still present on Bawean island. Nijman (2003) reported their absence from

some of the smaller forest fragments on the island. The exact geographic distribution and population numbers, which are important for effective conservation planning, however remain poorly studied, and a structured population survey is highly recommended by the WPSG (Meijaard et al. 2014).

As emphasized by its suggested Data Deficient status, ecology, behaviour and social structure of Bawean and Javan warty pigs remain largely unknown. This results in a knowledge gap which hinders the formulation of effective nature conservation measures. For instance, while there are no Bawean warty pigs in captivity, a conservation captive breeding program of the Javan warty pig has been established by Cikananga Wildlife Rescue Centre, Sukabumi, West Java, in 2007, with the ultimate purpose of reintroduction. Gaps in the knowledge about wild populations however leave the design of population management and reintroduction programmes to trial and error. To reach the ultimate goal of a successful reintroduction, data for instance on the ecology, preferred habitat, and social structure of the species is needed (IUCN/SSC 2013). In the absence of data for wild Javan warty pig populations, ecological and behaviour data of the closely related Bawean wart pig may assist in the design of programmes. Warty pigs are believed to live in smaller groups than Eurasian wild pig, and males seem to join the female core groups only during the mating season (Meijaard et al. 2014). Furthermore, interviews with local hunters revealed that warty pig may be rather shy and prefer to stay inside the forest, while Eurasian wild pigs roam the forest edges. The animals' extreme shyness in captivity (Meijaard et al. 2014) supports this view.

Nijman (2003) reports that although local people and officers of the forestry department were aware of the need to protect the also endemic, and Critically Endangered Bawean deer (*Axis kuhlii*), but not of the Bawean warty pig. In order to conserve the unique wildlife of Bawean, which is in a generally bad shape with illegal logging and burning ongoing, Nijman (2003) recommends a reorganizations of the responsible institutions (accompanied by technical training of staff), stricter law enforcement and demarcation of conservation areas, and implementation of appropriate education and awareness programmes.

The outcomes of the supported project will reveal novel information of Bawean warty pig distribution, population size, behaviour and ecology, and helps to give recommendations for habitat protection schemes, potential legislative species protection, community conservation involvement, and the design of captive management and reintroduction programmes. It also supported capacity building of the island's forestry officials and young Indonesian

conservationists. Finally, we report data on the Bawean deer as there is currently no comprehensive research published about the species and their conservation status may be critical.

3.2 Main aims and objectives

Our original main aim was to collect baseline data of the distribution, population size, biology, ecology and taxonomy of Bawean warty pigs, presenting the first thorough ecological study on the species. As local communities play a significant role in the conservation of this legally unprotected species, we also aimed to investigate the local people's perception of wild pigs, and wildlife and nature in general. Original aims and objectives had to be adjusted due to various reasons and are listed in Table 1.

Table 1: Original and adjusted objectives

ORIGINAL OBJECTIVE	INDICATORS	COMPLETION?
1. Studying the population size and distribution of Bawean warty pigs	• Using 25 camera traps for 1 year • Conducting 13 nocturnal transects, each repeated three times, leading to approximately 130 km covered	• **Yes**, 13 months, but only maximum 23 camera traps at one time due to burglary and vandalism • **No**, due to difficult terrain and time constraints. Random walks completed but no data processed.
2. Investigating the biology, ecology, habitat requirements and interspecific competition with wild boars	• See above for camera trapping and transects • Direct observation: at least 3 full nights	• See above for camera trapping and transects • **Yes**, 12 direct observation sessions conducted during peak activity times (No interspecific competition because no wild boar on island)
3. Confirming the taxonomic status and genetic diversity of Bawean warty pigs	• Continuous collection of at least 30 biological samples (faeces, hair, carcasses)	• **In progress**. During 13 months only 1 sample could be secured. The sample together with Javan warty pig samples successfully exported to the UK, now being analysed at Oxford

ORIGINAL OBJECTIVE	INDICATORS	COMPLETION?
		University (Dr. Laurent Frantz)
4. Investigating crop raiding behaviour of warty pigs	• 5 camera traps at crop-raiding sites for at least 1 month	• **No**, due to time constraints
5. Performing careful socialization, awareness and education especially in the villages adjacent forests where warty pigs occur.	• Distribution of education material: 1000 stickers, 500 information leaflets, 500 calendars with conservation message • Visit at least 4 schools	• **Yes**, distributed 1000 stickers and 500 leaflets and reached 150 students with their teachers
ADDED OBJECTIVES		
6. Investigating local people's perception of wild pigs and wildlife and nature in general	• At least 30 interviews with local people (farmers, local authorities, hunters)	• **Yes**, 52 interviews conducted

3.3 Supporting objectives

In order to achieve sustainable long-term outcomes, along with the objectives listed in Table 1 we intended to:

- Give intensive training to at least one Indonesian student and two local forest guides
- Promote international networks in conservation by collaborating with Indonesian researchers and students
- Enlarge the awareness for warty pigs by the dissemination of our data and resulting recommendations to the international scientific conservation community, the public and practitioners like rescue and education centres and authorities
- Record all other medium-sized nocturnal mammal species recorded by camera traps and during nocturnal surveys, as almost nothing is known about mammal community on Bawean island

3.4 Time frame

The project started on 1st of November 2014, as planned. Data have been collected until early December 2016 as the camera traps could not be collected from the forest earlier. The final report has been delayed as the project coordinator JRM had accepted a full-time job at Chester Zoo in January 2016 and because of data analysis could not be finished sooner.

3.5 The team

This project would have not been possible without a brilliant and dedicated team who worked in the field (Table 2). Due to their importance to the success of the project, and due to their potential of being future conservation and research leaders, they will be listed by name.

Table 2: Team member

NAME	ROLE
Dr. Gono Semiadi	Indonesian research counterpart from the Indonesian Institute of Science (LIPI)
Nur Syamsi	Head of Bawean protected area management
Abdul Rahim, Maskur, Halim, Taha, Abdullah	Forest rangers
Mark Rademaker	Student researcher, project initiator
Simen Blokland	Student researcher
Shafia Zahra, Putri Diana, Amelia Tagaroi	Research assistants – team leaders
Sandy Leo, Silvi Dwi Anasari, Dinda Rahayu Istiqomah, Rifanti Diana Lutfi	Research assistants
Hendra Margono	Logistics
Iing Iryantoro, Muhammad Fadhil Gooner	Media
Dr. Johanna Rode-Margono	Project coordinator

4. Methods

4.1 Field site

Bawean is a small island of approximately 190 km^2, situated in the Java Sea 120 km north of Surabaya, East Java, Indonesia (Figure 1). The island consists of the remains of an old volcano and has several peaks at 600 m elevation. The island used to be part of the larger Sundaland landmass that existed until the Late Miocene some 5 million years ago (Smit Sibbinga 1947). During the last glacial maximum (ca. 12,000 years ago), when sea levels were much lower, the island was connected to both the present land areas of Java and Borneo. After its split from the other islands approximately 10,000 years ago Bawean was covered with dense forest. Although forest cover has been reduced by habitat destruction and modification to agricultural land and teak plantations in the last centuries, the island's

interior still largely forested, except for fertile plains. The protected areas of Bawean roughly coincide with forest borders on the island and are divided into five wildlife reserves (total 38 km^2), six strict nature reserves (total 7 km^2) and three community wildlife reserves (total 1.6 km^2) (Semiadi & Meijaard 2013, Rademaker et al. 2016). This makes almost one quarter of the island protected habitat. Despite these designations, small scale illegal logging and burning continue to occur in protected forests due to a lack of clear area boundaries and law enforcement (Nijman 2006, Nur Syamsi, personal communication). The climate on the island is relatively dry with heavy rains from December to April, and a dry season from May to November. For the study period of November 2014 to December 2015, the average monthly temperature on the island ranges from 27.4°C to 29°C, while daily averages ranged between 24°C to 31°C. The annual rainfall for the study period was at least 2265 mm (66 days not recorded).

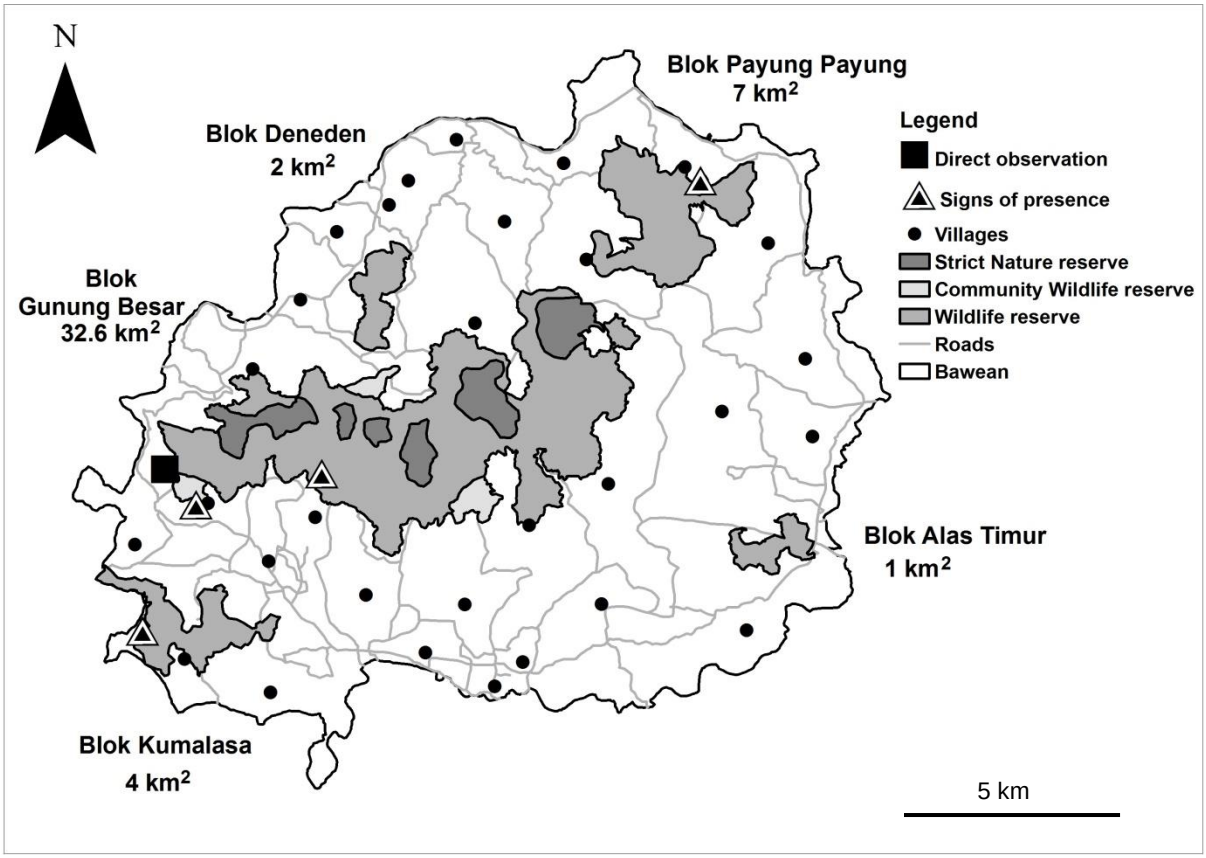

Figure 1: The island of Bawean with protected areas that also roughly coincide with forest borders. Villages and location, where direct observations have been made, are indicated.

In 2010, approximately 70,000 people lived in 30 villages, that were mostly located in the coastal plains (Hugo 1995, Irwanto 2015). People mainly depend on fishing and farming (Nijman 2004). A large proportion of the male population temporarily lives in Malaysia, Singapore and other parts of Indonesia to work. This has led to the island being called

Princess Island (*Pulau Putri*) or Island of the Women (*Pulau Wanita*) (Hugo 1995, Irwanto 2015). Nearly all inhabitants of Bawean adhere to Islam (Farid et al. 2013a). The two districts of the island, Sangkapura and Tambak comprise 30 villages.

4.2 Data collection

Camera trapping *(published: Rademaker et al. 2016)*

We installed up to 23 infrared camera traps (Cuddeback Seen Trailcam) at the same time (O'Connell et al. 2011), that ran between 4th of November 2014 and 3rd of December 2015. We randomly installed camera traps in all protected, forested areas on Bawean (Figure 1), to fulfil the assumption posed by the Random Encounter Model (Rowcliffe et al. 2008), an analysis that does not require the identification of individuals. Details on how locations have been chosen can be found in Rademaker et al. (2016, see Appendix). Camera traps were mounted on tree trunks, at approximately 50 cm height, and pointed in a direction relatively free of close vegetation to avoid false-triggering. As locations were selected randomly, we neither avoided nor sought out areas that would seem likely for wild pigs to be preferred. We set cameras at 30 seconds video mode with 1 minute intervals. At each camera trap location we took GPS coordinates.

Habitat, spatial requirements, environmental data *(partly published: Rademaker et al. 2016)*

At 142 camera trap locations, we conducted habitat assessments, and collected the following variables: major habitat type, presence of a wallow, presence of a river, average litter depth, average DBH and average tree height. Details on collection and definition of these categories can be found in Rademaker et al. (2016, see Appendix). By plotting the camera locations on QGIS, we were able to record distance to the forest border, distance to the border of the protected area, distance to the next village, and altitude. We retrieved temperature and rainfall for most days from the meteorology station on Bawean (*Stasiun Meteorologi Sangkapura Bawean*). Luminosity was recorded using the exact percentage of the moon illuminated when above the horizon, using the programme MOONDV version 1 (Thomas 1998). When below the horizon an illumination of 0 was recorded.

Behaviour *(partly published: Rode et al. 2016)*

When reviewing camera trap videos, we recorded the number of group members visible on the video (minimum group number), and the number of adult males, adult females, juveniles, piglets, and animals of unknown sex and age. The date and time of videos taken were used to establish an activity profile and to investigate reproductive season and behaviour. For long-tailed macaques and other species equivalent data were recorded, but not analysed

(except for Bawean deer). We conducted direct observations at a dry wallow located in a half-open community forest of clove (*Syzygium aromaticum*, Indonesian: Cengkeh), in early August and November 2015, which is around the middle to the end of the dry season. We entered the location where animals have been encountered regularly, in the afternoon at 16:00 and waited for the animals to appear. Observation points were chosen at strategic locations amongst vegetation or on trees. Once a group of warty pigs appeared the following data were collected: group size, number of males, females, juveniles and piglets. We used an ethogram adapted from Rademaker et al. (2015) with the behaviours feeding and foraging, resting, moving, aggressive behaviour, play with conspecifics, wallowing, allogroom and being alert / running away. We used instantaneous scan sampling with an interval of 2 minutes. Although observation data are likely to be dependent, we used this short interval because of short total observation periods (see Rode-Margono et al. 2016, Appendix).

Attitudes towards Bawean warty pigs, other wildlife and nature in general *(manuscript submitted)*

We interviewed 52 respondents, comprising the two stakeholder groups “authorities” (n = 31) and “farmers” (n = 21). Members of the group “authorities” were for instance community authorities such as village heads, but some also worked in the protected area management as forest rangers or forest police. We used semi-structured interviews with open-ended questions and free-listing (Bernard, 2006). All interviews were conducted in Indonesian language, with the help of one of the field assistants. All respondents were informed about the purpose of the study and participated voluntarily. Questions collected descriptive information about the personal and socioeconomic background of respondents, details about crop raiding and crop-raiding species, and hunting practices. We furthermore explored four different attitude domains (crop-raiding species, ecosystem services, general attitude about wildlife, general attitude about nature) by (1) ranking items that were extracted from a previous free-listing exercise with different respondents and (2) structured dichotomous questions. Details can be found in Rode et al. (submitted, see Appendix).

Socialisation, awareness, education

Initial socialisation with communities and village chiefs started right from the beginning to gain rapport and was ongoing throughout the project. In an early state of the project (early 2015) we distributed information leaflets (see Figure 6) that introduce warty pig facts and explains our work and the reasons for it, as well as stickers with conservation messages. We have not printed calendars due to a bad timing in the year. We selected schools based on recommendations of Mr. Nur Syamsi. We gave presentations about the importance of nature

and on endemic wildlife of Bawean, including the Bawean warty pig, all presentations being in Indonesian language. We furthermore included fun activities such as drawings.

4.3 Data analysis

Population size *(published: Rademaker et al. 2016)*

Individual animals pausing in front of the camera can trigger the camera multiple times resulting in non-independent observations. We reduced the bias from multiple detections of the same individuals by setting a 1-hour independence interval for videos of individuals of the same sex and age class (Rovero et al. 2013). We also report the relative abundance index (RAI) for each species, defined as the number of independent videos of a species taken in 100 camera trap days. To calculate the population size of Bawean warty pigs, we used the Random Encounter Model, following Rowcliffe et al. (2008, 2011, 2014), based on the first three months of data collection. Details are described in Rademaker et al. (2016, see Appendix).

Habitat, spatial requirements, environmental data *(partly published: Rademaker et al. 2016)*

We used a Generalized Linear Model and Occupancy Modelling with data from the first three months to investigate the influence of habitat type, tree density, altitude, distance to nearest border and litter depth on the camera trap rate. The exact analysis is described in Rademaker et al. (2016). The 13 months data set with RAI as the dependent variable and all habitat variables as independent variables is analysed using standard nonparametric statistical tests such as Kruskal-Wallis, Mann Whitney U and Spearman Correlation tests, and may be tested by additional Generalized Linear Model and Occupancy Model in the future. We tested the effects of climatic factors and lunar illumination on the detection of Bawean warty pigs by using a logistic regression model with presence or absence of a video as the binary dependent variable (Starr et al. 2012, Rode-Margono et al. 2014). The sample unit for this analysis was one night where a camera trap was operated, with day time (6:00 – 18:00) and twilight hours (5:00 – 6:00; 18:00 – 19:00) excluded from the dataset. The predictor variables were lunar luminosity, daily minimum temperature, maximum temperature, precipitation and survey effort (number of camera traps operating).

Behaviour *(partly published: Rode et al. 2016)*

We report mean group sizes and mean numbers of each sex and age class, with standard deviations. We used simple bar charts to plot the time when videos were recorded over the

24 hours of the day. Similarly, we plotted the distribution of group numbers and group composition (sex and age) over the year in order to explore reproductive seasons. Activity budgets of direct observations were calculated once based on single observation points and once based on percentages of animals in a group engaging in certain behaviour during one observation. Details can be found in Rode-Margono et al. (2016, see Appendix).

Attitudes towards Bawean warty pigs, other wildlife and nature in general *(manuscript submitted)*

Questions were analysed descriptively using percentages, means and standard deviations. Ranking and dichotomous questions were analysed based on a Cultural Consensus Analysis (CCA). CCA can be used to characterise attitudes of local people and explore how these perceptions are shared among respondents (Weller 2007, Borgatti & Halgin 2011, Stone-Jovicich et al. 2011). It also gives a "culturally correct" answer on questions. Details on the analysis can be found in Rode-Margono (submitted, see Appendix).

Socialisation, awareness, education

Due to time constraints awareness activities could not been evaluated formally. Results are summarised in numbers of schools, school classes and pupils reached.

5. Results

5.1 Scientific results: Bawean warty pigs

Distribution and population size *(partly published: Rademaker et al. 2016)*

Between 4th of November 2014 and 3rd of December 2015 we collected 4516 camera trap days, with a maximum of 23 camera traps operating at the same time. We recorded a total of 2278 independent wildlife videos, including 985 warty pig videos (Table 3). Domestic species recorded were water buffalo (2), dog (44), cat (14) and chicken (3). Also we recorded 28 videos of unidentified species of rats. Relative Abundance Indices can be found in Table 3. No European wild pig was recorded, confirming that this species is absent from the island. Bawean warty pigs were not recorded in two fragmented forest sites (Alas Timur and Deneden) (see Figure 1). Based on the first three months (100 camera trap locations, 690 camera trap days, 92 independent videos of Bawean warty pigs), we estimated 172−377 individuals to be present on the island (including immature animals), using the Random

Encounter Model. Using Occupancy Modelling, the estimated amount of sites occupied reached 58%. Details can be found in Rademaker et al. (2016, see Appendix).

Table 3: Relative Abundance Indices (RAI) for all species recorded on camera traps (except domestic species and rats). RAI is defined as the number of independent videos of a species taken in 100 camera trap days. The small Indian civet was only observed during random forest walks.

Scientific name	English name	IUCN	Protection	RAI	Videos	CT days until first detection	%
Macaca fascicularis	Long-tailed Macaque	LC	NP	38.33	1731	115	62.3
Sus blouchi	Bawean warty pig	EN	NP	21.81	985	49	35.5
Axis kuhlii	Bawean deer	CR	P	0.81	38	507	1.4
Paradoxurus hermaphroditus	Common palm civet	LC	NP	0.16	7	1188	0.3
Varanus salvator	Common water	LC	NP	0.13	6	526	0.2
Gallus varius	Green junglefowl	LC	NP	0.11	5	1722	0.2
Hystrix javanica	Sunda Porcupine	LC	P	0.07	3	265	0.1
Ardea purpurea	Purple heron	LC	NP	0.04	2	595	0.1
Chalcophaps indica	Emerald dove	LC	NP	0.02	1	3928	0.0
Viverricula indica	Small Indian civet	LC	NP	0	0	-	0.0

Habitat, spatial requirements, environmental data *(partly published: Rademaker et al. 2016)*
Using the data of the first three months, generalised linear models showed that Bawean warty pigs prefer community forests and areas near forest borders. Additionally, we found a positive relationship between occupancy, distance to nearest border, litter depth and tree density in the highest ranking occupancy models. Although these relationships proved non-significant based on model averaging, their presence in the top ranking models suggests that these co-variables do play a role in predicting warty pig occurrence on Bawean. Details can be found in Rademaker et al. (2016, see Appendix). Using the full dataset, there is a significant difference between habitat types (Kruskal Wallis =14.151, df = 7m p=0.049, n=144), with highest RAIs for community forest and garden cultivation areas, however,

variation was high with several outliers. Tree height was the only microhabitat variable that correlated with RAI, with higher RAI being associated with higher trees (Table 4).

Table 4: Effect of microhabitat variables on RAI of Bawean warty pigs. Correlations present Spearman's rho correlations, used due to non-normal distribution of the dependent variable.

Variable	Mean	sd	n	Correlation	p
DBH (cm)	17.1	11.0	141	0.040	0.639
Tree height (m)	5.9	1.8	43	0.489	0.001
Litter depth (cm)	3.8	2.3	142	-0.120	0.155

There was no difference in RAIs across seasons (Mann Whitney U = 4050, p=0.279, n=176). The logistic regression model with presence of absence of Bawean warty pigs videos at a certain camera trap location as the outcome variable was highly significant (χ^2 (1) = 129.189, df = 5, p < 0.001, n=401), with maximum temperature having a negative and effort having a positive significant effect (Table 5). Lunar illumination, minimum temperature and rainfall did not have significant effects.

Table 5: Results of the logistic regression model with presence or absence of Bawean warty pig videos as binary outcome variable

			95 % C.I. for EXP(B)		
	B (SE)	Sig.	Lower	Odds ratio	Upper
Constant	8.491 (4.145)	0.041		4870.632	
Max. temp.	-0.295 (0.099)	0.003	0.613	0.744	0.903
Min. temp.	-0.061 (0.138)	0.660	0.718	0.941	1.233
Precipitation	-0.012 (0.010)	0.245	0.968	0.988	1.008
Lunar illum.	0.000 (0.001)	0.973	0.999	1.000	1.001
Effort	0.175 (0.021)	<0.001	1.145	1.202	1.241

Note: R^2= 0.315 (Cox and Snell), 0.420 (Nagelkerke), Model χ^2 (1) = 129.189, df = 5, p<0.001, n=401

Behaviour *(partly published: Rode et al. 2016)*

We directly observed a total of 12 groups during 8 days, with a total observation time of more than three hours (between 4 and 53 minutes per group), leading to a total of 480 single observation points during 89 intervals. Although three hours do not sound much, it is the first time this species has been directly observed in the wild, and thus present valuable data.

Animals that were directly observed only appeared in the open area around 17:00 and returned to the protected forest around 18:00. When analysing the 13 months camera trap

data, most videos were taken at twilight hours, followed by nocturnal times and least at diurnal times (Figure 2).

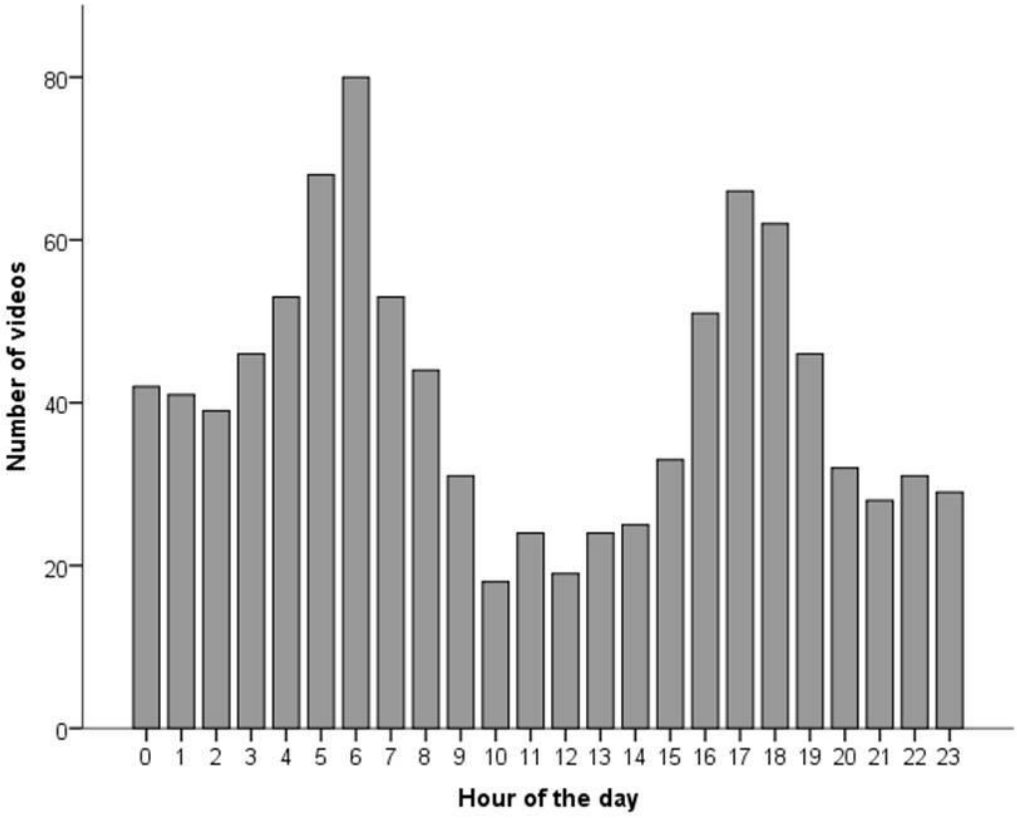

Figure 2: Activity profile of Bawean warty pigs during 13 months of data collection (n=985)

Group sizes and numbers of male adults, female adults, juveniles and piglets differed between the direct observations in August and November and the 13 months dataset of camera trap videos (Table 6, Figure 3). On average 11% (±0.3%) of the groups contained adult males, regardless of whether immatures were also present, however, number of videos with males in the group varied considerable across month. Group sizes were lower in the night, as compared to day and twilight hours (Kruskal Wallis = 54.731, df = 2, $p < 0.001$, n = 985). Group size during the night was not dependent on moon category (Mann-Whitney U = 20358.5, p = 854, n = 411).

Figure 3: Group of Bawean warty pigs

Table 6: Numbers of individuals, adult males, adult females, juveniles and piglets in a group, based on 12 direct observation sessions in August and November 2015, and on camera trap data (CT) from November 2014 to December 2015. Numbers in brackets present numbers of juveniles or piglets in a group where those age classes were actually present.

	Individuals		Males		Females		Juveniles		Piglets	
	Obs.	CT	Obs.	CT	Obs.	CT	Obs.	CT	Obs.	CT
Mean	4.6	2.1	1.0	0.3	1.3	0.5	2.3	0.3 (1.5)	2.5	0.7 (2.2)
Sd	1.8	1.5	0.8	0.5	0.5	0.6	1.3	0.7 (0.8)	1.2	1.2 (1.1)
Min.	1	1	0	0	0	0	1	0	1	0
Max.	7	9	2	2	2	4	4	5	4	6

Directly observed animals were feeding and foraging for 69% of the observations, were alert and running away for 7%, moving for 6%, resting 5%, wallowing 1%, and social behaviours 10% (playing, allogroom, aggression). Immatures spent significantly more time playing (χ^2=21.801, df = 7, p=0.003, n=377), and group size was positively related to time spent feeding and foraging (Spearman's rho = 0.370, p=0.004). In general, Bawean warty pigs were relatively bold; during direct observation sessions they approached the observers up to 3 meters. Details can be found in Rode-Margono et al. (2016, see Appendix).

Group size captured on camera traps differed significantly across months (Kruskal Wallis = 48.397, df = 11, p<0.001, n=985) and between seasons (Mann-Whitney U = 57485, p = 0.003, n=985), with higher group sizes in the dry season. The group composition differed as well between months with piglets not present from November to February (Figure 4), and a peak of piglet presence in videos in August, where 65.9% of the groups contained piglets (but only 0.6% juveniles).

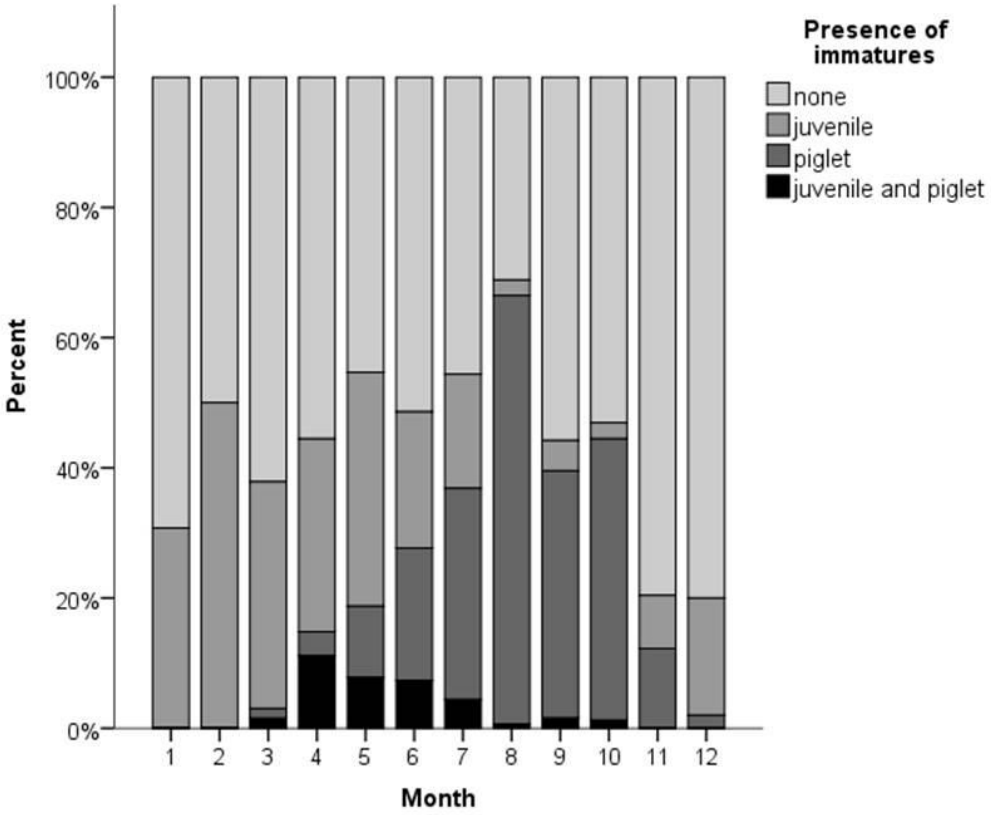

Figure 4: Group composition of Bawean warty pigs across all months of the year (n=985)

Attitudes towards Bawean warty pigs, other wildlife and nature in general *(manuscript submitted)*

Although variance was high, perceived crop loss was substantial. Mean crop loss caused by all crop-raiding species averaged between all crop types was 28.9% (sd 11.2) and ranged around 40% loss for fruit, and around one third for other crop types. Different wildlife species were reported to affect different crop types. Pigs were only mentioned by up to five respondents for each crop type, with most damage done to rice, cassava, and coconut and banana plants, and no damage done to teak and mahogany. Generally, people ranked pigs fourth after rats, macaques and insects as the most severe crop raiders (out of 15 species) (Figure 5). The most commonly reported methods to protect crops against pigs were hunting using nets, sticks, traditional knives (*golok, parang*), traditional spears (*tombak*) and dogs, as well as trapping (snaring and pits), both methods ultimately lethal to the pigs. No poisoning was mentioned by interviewees. Respondents reported that all pigs are killed after being trapped and no pigs are sold for consumption. Carcasses are left where the animal is killed, and eaten by dogs, other pigs or monitor lizards, burrowed or burnt. CCA revealed that attitudes in the tested domains were in agreement amongst respondents, except for the

domain wildlife. Respondents regarded water, sun and food as the most important ecosystem services, while research and wildlife were seen as least important (Figure 6). Details, including crop-raiding by other species and details on the CCA results, can be found in Rode-Margono et al. (submitted, see Appendix).

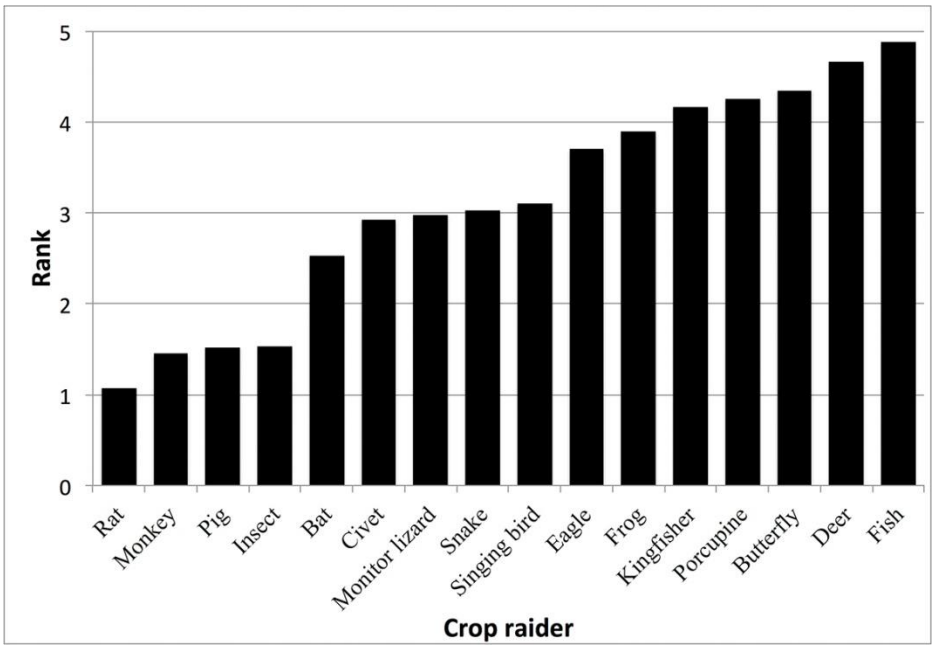

Figure 5: Severity of crop-raiding wildlife species, indicated by ranks, according to the perception of 52 respondents.

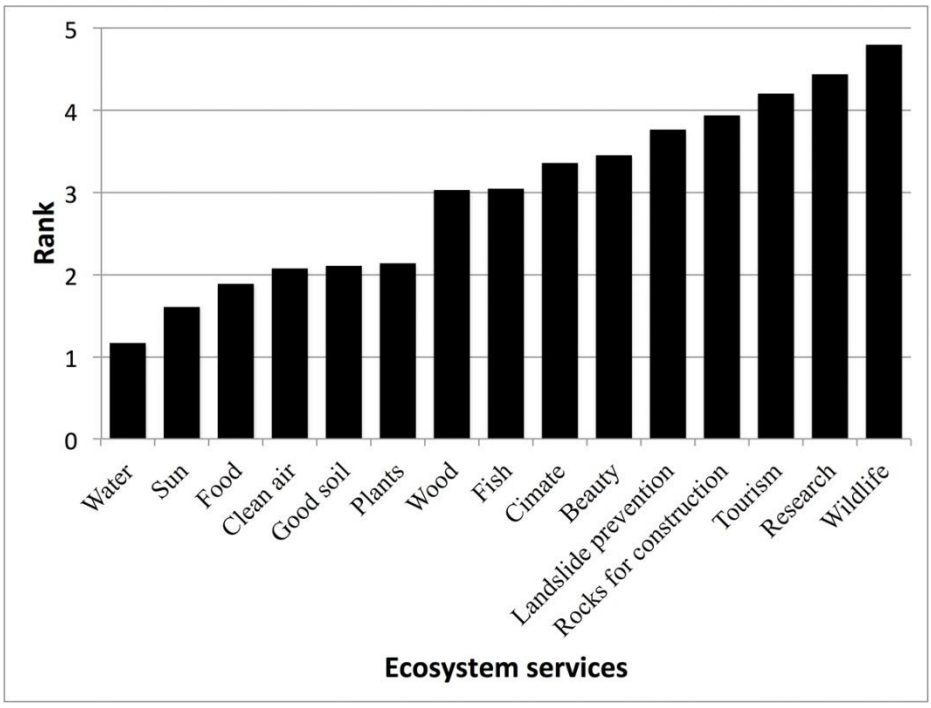

Figure 6: Importance of ecosystem services, indicated by ranks, according to the perception of 52 respondents

Socialisation, awareness, education

In total, we distributed 500 information leaflets and 1000 stickers (Figure 6). Even though pigs are regarded as impure in Islam, especially children loved the stickers. We visited three schools: one primary schools, age 10-12, one middle school, age 13-15, and one high school, age 15-18. Our presentations reached approximately 150 students and their teachers (Figure 7).

Figure 7: Education and awareness activities performed by BEKI (A, B: Information leaflet front and back, C: school children with BEKI field assistant Putri Diana, D: Stickers)

5.2 Scientific results: Bawean deer

In 13 months we had only 38 videos of Bawean deer and needed over 500 camera trap days until first detection. Except three videos, all videos have been recorded in a single area covering about 17 hectares (92% of all videos), with 29 videos taken from only 2 camera traps. Activity is distributed over the hours of the day and night, with apparent peaks around dusk and at 3am (Figure 8), however the low sample size does not allow generalisations.

Figure 8: Male Bawean deer

Group size was 1 or 2 animals, with a mean of 1.1±0.3. Two of three observed pairs consisted of doe and fawn, one consisted of a doe following a buck. The does were observed in April and August (Figure 9).

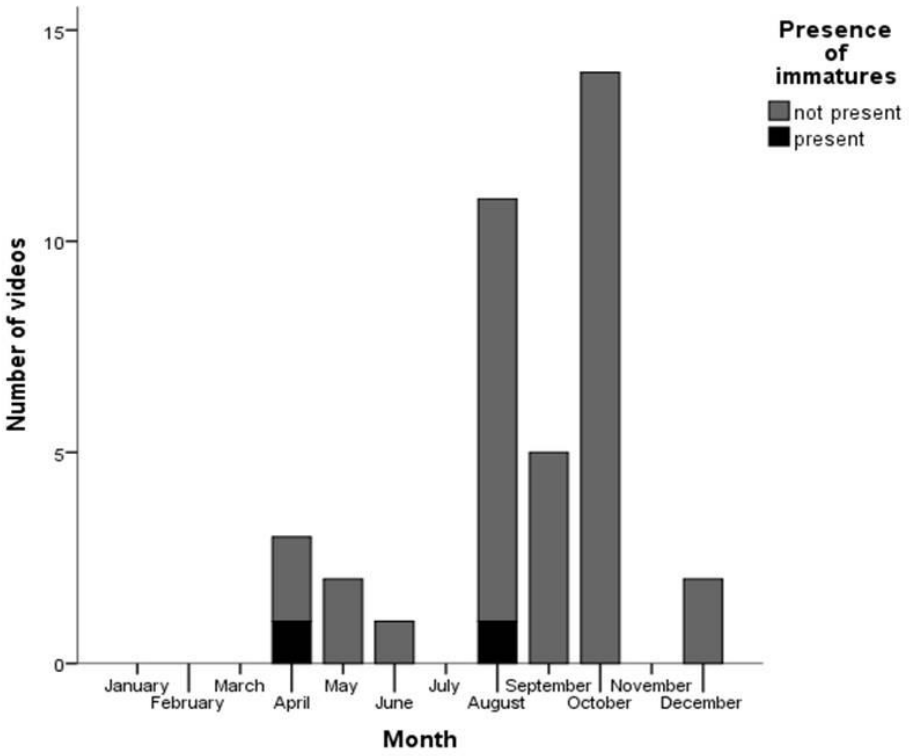

Figure 9: Number of videos of Bawean deer across months, and presence of immatures in groups

5.3 Supporting objectives

This project involved six Indonesian students or fresh graduates, two international students, six members of staff of the Bawean protected area management, one Indonesian senior researcher, and four other Indonesian nationals. Although the project coordinator and initiator are foreign nationals, this makes 85% of people involved being Indonesians (see Table 2). All people who were engaged in field activities were trained in the used methods (installing and setting camera traps, using GPS, recording behaviour data etc.). Additionally, in July 2016 we plan to conduct a final workshop for the staff of the Bawean protected area management to repeat all learnt skills and compile a script in Indonesian language that can serve as a resource for future monitoring. We printed 45 BEKI long sleeves suitable for fieldwork that were used as a

Figure 10: BEKI uniform

uniform and branding of the project (Figure 10). This also aimed to create a common identity and pride of the protected area management staff.

As it can be seen in the publications, all students and graduates have been involved in data analysis and writing up output. International collaboration is on-going. Communication with the Indonesian counterpart, Dr.Gono Semiadi from LIPI, was very good and continues to be. One graduate team leader (PD) is now helping in the analysis of the 13 months dataset, and another (SZ) has been appointed to lead a full year conservation project on Javan warty pigs.

To date we have published one article in PlosOne (population size, habitat preferences) and several articles in Suiform Soundings (e.g. behaviour) (Table 7). PlosOne published a press release that was taken up by the (online) media. At least 15 public science websites have picked up the press release, amongst others:

- National Geographic (International)
  http://news.nationalgeographic.com/2016/04/160406-warty-pigs-animals-science-endangered-species/
- BBC Earth
  http://www.bbc.com/earth/story/20160406-the-worlds-ugliest-pig-can-only-be-found-on-one-tiny-island
- Mongabay
  http://news.mongabay.com/2016/04/less-than-250-rare-bawean-warty-pigs-remain-on-indonesian-island/
- Science daily
  https://www.sciencedaily.com/releases/2016/04/160406165238.html
- New Scientist
  https://www.newscientist.com/article/2083311-bawean-warty-pig-may-be-worlds-rarest-pig-with-only-230-around/
- Newsbeat Social (Video)
  http://newsbeatsocial.com/watch/0_81lxzny5
- Inverse
  https://www.inverse.com/article/13919-why-only-250-bawean-warty-pigs-are-left-in-t

Individualised reports will be distributed to rescue centres and national authorities in the near future. Submitted and currently prepared manuscripts are also listed in Table 7.

Information about other medium-sized nocturnal mammal species on Bawean island has been integrated into the results and discussion section.

Table 7: Output of project until June 2016

Output	Type	Status	Appendix
Rademaker M, Meijaard E, Semiadi G, Blokland S, Neilson EW, Rode-Margono EJ (2016) First ecological study of the Bawean warty pig (*Sus blouchi*), one of the rarest pigs on earth. Plosone DOI:10.1371/journal.pone.0151732.	Scientific article (peer-reviewed)	Published	Yes
Rode-Margono EJ, Diana P, Zahra S, Istiqomah DR, Lutfi RD, Leo S, Anasari SD, Rademaker M, Semiadi G (2016) Direct observations on the behaviour and group patterns of Bawean warty pigs (*Sus blouchi*) on Bawean island, Indonesia. Suiform Soundings 14(2):15-20.	Scientific article	Published	Yes
Rode-Margono EJ, Rademaker M (2015) Preliminary results of the first ecological study on Bawean warty pigs *Sus blouchi*. Suiform Soundings 13(2):16-18.	Update	Published	Yes
Rode-Margono EJ, Blokland S, Zahra S, Rademaker M, Semiadi G (submitted) Crop raiding and local people's attitudes on Bawean island, Indonesia, with a focus on the Endangered Bawean warty pigs (*Sus blouchi*). Asian Journal of Conservation.	Scientific article (peer-reviewed)	Submitted November 2015	Yes
Rode-Margono EJ, Rademaker M, Semiadi G, Bulk S (submitted) Javan warty pig *Sus verrucosus* Boie, 1832 and Bawean warty pig *Sus blouchi* Groves and Grubb 2011. In: Meletti M, Meijaard E (eds.) Ecology and conservation of wild pigs and peccaries. Cambridge, UK, Cambridge University Press.	Book chapter (peer-reviewed)	Submitted February 2016	No
Rademaker M (2015) Draft of the Red List Assessment of Bawean warty pigs (*Sus verrucosus blouchi*)	Red List update	Unpublished	No
BEKI (2016) BEKI video 5 minutes. Online: https://www.youtube.com/watch?v=qpilDmTdYOQ (last access 22 June 2016).	Video	Published online	Yes
7 issues of the BEKI newsletter "Pig Pipeline". Online: www.jesprogramme.weebly.com (last access 22 June 2016).	Newsletter	Published online	Yes
Zahra S, Rode-Margono EJ, Blokland S, Rademaker M (2015) Conceptions of two local stakeholder groups towards the crop-raiding Bawean warty pig (*Sus*	Conference poster	Presented	Yes

blouchi), endemic to Bawean island, Indonesia. Poster presented at: Student Conference on Conservation Science, Bangalore, India, 8-11 September 2015.

6. Discussions

6.1 Discussion of scientific results: Bawean warty pigs

Most of our results are completely novel as there has not been any structured study been conducted on distribution, population size, behaviour and ecology. We found that between 172−377 Bawean warty pigs live on Bawean. Although the number will be lower for mature individuals, we have currently no reason to believe that there is a major decline in population size. That means that the species should be listed Red-Listed as Endangered according to Criteria D (less than 250 mature animals) (IUCN SSC 2005). In any case measures have to be taken to ensure that the population is monitored regularly to detect potential future population declines. It is re-assuring that the European wild pig is not present on the island, and the potential threat posed by hybridisation (Meijaard et al. 2014) can be ruled out.

Recorded group sizes from direct observations were more than twice as high as group sizes recorded on camera traps (means of 4.6 vs. 2.2). This could be due to methodological, spatial (wallow presence), seasonal or day time effect. We do not feel that a substantial number of group members were missed by videos. Based on camera trap videos only, we in deed found that group sizes were significantly higher during the day. This could be a reflection of predator protection. The fact that group size and feeding and foraging were correlated points to a relation between group size and perceived predator pressure. Group sizes in European wild pigs are similar (e.g. means of 3.2 in Fernández-Llario et al. 1996, 4.4 in Rosell et al. 2004, 3.9 in Gabor et al. 1999).

Animals seemed to prefer community forest over other forest types. The most likely explanation for the preference for community forests is the availability of more energy-rich foods e.g. roots and tubers in these cultivated areas compared to other habitats (Genov et al. 1986). Incorporating behaviours observed during direct observation, half-open community forests and wallow areas seem to be important for feeding, foraging and social activities.

Litter size (means of 2.5 and 2.2) were less than half of litter sizes for European wild pigs (e.g. means of 6.6. in Saunders 1993, 5.6 in Gabor et al. 1999), possibly a reason why Javan warty pigs seem to be outcompeted on Java island. While RAI was not affected by season or month, group size was affected by these factors with larger groups in the dry season, possibly caused by the presence of immatures. Group composition differed across months. The pattern of immature presence in groups gives a relatively clear idea about the breeding season spreading with piglets present from March to October, with a peak in April. Males did join groups (including groups with immatures), roamed in bachelor groups or alone, with no consistent pattern across months.

Most videos were taken during twilight, followed by night time, confirming a rather nocturnal or crepuscular activity pattern. Of the climatic variables tested, only maximum temperature affected whether a video was taken in a night or not. In deed in the hottest months (October and November) many fires were observed by the team and recorded on camera traps, potentially pushing the animals back into denser forest. Bawean warty pigs were surprisingly bold, as opposed to experiences with Javan warty pigs in captivity (Meijaard et al. 2014).

Our results show that Bawean people feel affected by crop raiding, although the majority of people named other species than pigs as the main contributors to crop-raids. The hunting pressure is unquantified but consistent (Nur Syamsi, personal communication). There is an absence of poisoning of pigs (as opposed to Java, Nijman 2003), but hunting always leads to the death of animals. The development of non-lethal protection methods would benefit the conservation of Bawean warty pigs. General perceptions of nature and wildlife are still positive. We expect that conservation initiatives would be accepted by local people and that our results could be used for the design of conservation projects and environmental education programmes.

Regarding mammals, we have recorded camera trap videos of Bawean warty pigs, Bawean deer, long-tailed macaque, Sunda porcupine and common palm civet, and sighted two Indian small civets during separate occasions. Long-tailed macaques and common palm civets were not listed as mammal species present on Bawean island by Meijaard (2003), while we could not record any Sunda pangolins that were listed as present by the author. We are especially concerned about the status of pangolins and porcupines on the island, as these species are (mainly) terrestrial (although pangolins do climb) and should be more easily recorded. In the next section we elaborate on the status of Bawean deer.

6.2 Discussion of scientific results: Bawean deer

The Bawean deer is Red-Listed as Critically Endangered, based on less than 250 mature animals, a continuing decline in numbers and 90-100% of animals in one sub-population (IUCN 2015, IUCN SSC 2005). In 2006, the wild population was estimated (based on field-work in 1998–2003) to be stable at 250–300 animals (Semiadi 2004), but there has been no systematic survey; 500 was regarded as an absolute maximum (G. Semiadi pers. comm. 2008).

Looking at our results, we think there is absolutely no possibility of 250-300 animals existing on Bawean island. We did estimate a population size of 172−377 for warty pigs, based on the first three months of data collection. During this time we collected independent 88 warty pig videos but only 2 deer video (total for 13 months: 985 Bawean warty pig videos, 38 Bawean deer videos). Of the total of 38 independent deer videos, 92% were recorded in an area of 17 hectares (as opposed to 46.6 km^2 protected forested area on Bawean). The camera traps were set randomly in all areas of Bawean, with no bias towards potentially preferred areas by warty pigs, or avoided by deer, and also no preference of denser vs. more open habitats. It is possible that Bawean deer prefer very inaccessible terrain (that had to be omitted from the setting of camera traps) and extremely dense bush areas (that could not be used due to the risk of false triggering by vegetation). However, as in existent videos dears used open areas to walk instead of bushes, we do not believe this. We regard it as very likely that the deer population has gone down extremely and is found in only a few restricted places. Only 2 of 38 videos showed an immature animal, fuelling our concern about the status of the population.

Since 2000, a captive breeding programme has been operative on Bawean; in 2006 it involved a founder population of two stags and five hinds, and by 2014 numbered 35 animals (IUCN 2015). About 300–350 animals are held in zoos and private captive breeding facilities off the island (IUCN 2015).

We highly recommend pushing for a thorough assessment of the population of Bawean deer, if possible a continuation of camera trapping. To our knowledge, a population size study has been conducted by Mr. Dede Aulia Rahman, supported by a Rufford Small Grant, but we have not yet been able to get hold of a final project report that showed results and methods used. It will be interesting to compare results (assuming that methods used allow a comparison).

7. Outlook and long-term implications

Regarding the output of this project, we will be working on the submitted manuscripts and prepare one or two publications based on the camera trap data from the 13 months. We furthermore will distribute customised reports to Indonesian conservation and forestry authorities, including the offices responsible for Bawean, to the respective IUCN SSC specialist groups (wild pigs and deer), Cikananga Conservation breeding Centre with information assisting captive breeding of Javan warty pigs and future reintroduction plans, and to zoos holding Javan warty pigs.

MR and JRM were invited to join the IUCN SSC Wild Pig Specialist Groups as members. JRM will present this study at the Wild Boar Conference in Luxemburg in September 2016, and will give updates on the Bawean deer results at the Annual Conference of the European Association of Zoos and Aquaria in September 2016.

To support long-term monitoring especially of Bawean warty pigs and Bawean deer, we will conduct a final training workshop for the protected area management staff and forest rangers of Bawean island regarding the development of skills in camera trapping, GPS data collection and analysis. Nevertheless, our project has now officially ended, and the continuation of monitoring and conservation is back in the hands of the local forestry offices and local people. The work of the protected area managements depend hugely on the financial, technical and staff support of the Indonesian government. We have been told by the protected area management staff that sometimes salary is not paid, and there is an absence of equipment and skills development. However, we are confident that we stimulated and still stimulate scientific and conservation as well as public interest in Bawean warty pigs. We will do our best to stretch this interest to the respective regional forestry offices in order to emphasise the problems that local officers are facing. On the community level, we feel that our awareness activities have raised some profile of the pigs. Regarding the support of the younger generation of conservationists, we are currently continuing with a 1-year project on the Javan warty pig, aiming to identify the last wild populations on Java, that is led by one of the Indonesian field assistants (SZ) and coordinated by JRM. During the conduction of this project, we will stay in close contact with the forestry officials on Bawean island and assist them where ever we can.

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9. Accounting

Category	Items	Pounds
Accommodation	• Home stay on Bawean island, hostel in Gresik or Surabaya (11 field team members)	1583.92
Administration	• Research permits, research visa, protected area tickets, research exit fee for 2 foreign researchers • Phone credit for field assistants	2403.98
Consumables	• Batteries for camera traps (8 AA per camera trap), notebooks, stationary	391.72
Education and capacity building	• 500 leaflets, 1000 stickers, 4 banners • 45 uniform long-sleeves • Stationary for school visits	347.73
Equipment	• 37 camera traps with safe boxes, sd cards, tax • 8 headlamps • 1 GPS • 1 binoculars • Rental of filming equipment (lens, tripod) • 1 equipment container	5545.26
Food	• Food for field assistants during field work and travelling (11 field team members)	432.29
Salary	• Salary for 5 forest rangers (not all working at same time) • Bonus for head of protected area management • Salary for 3 field assistant – team leaders • Bonus for 4 field assistants and 2 media assistants	1087.86
Transportation	• Local transportation: train Jakarta/Bogor - Surabaya, ferry Gresik-Bawean, bus, motorbike rental (11 field team members)	1517.82
Grand Total		**13310.58**