grazing. Removal of the understory vegetation precludes habitation by wood-partridge. © Claudia Mota-Vargas and Jack Eitniear.

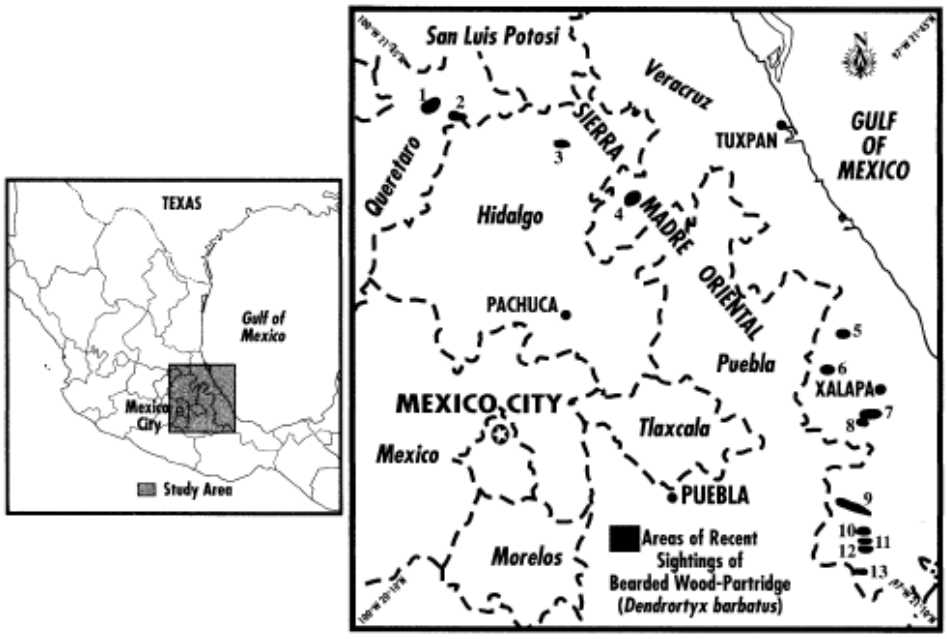

FIG. 1—Distribution of *Dendrortyx barbatus* in east-central México. Specific sites of observations are shown by numbers. 1) San Juan de los Duran, Querétaro. 2) Joya de Hielo, Querétaro. 3) Cañada de Avispas, Querétaro. 4) Lontla, Hidalgo. 5) Tenamicoya, Veracruz, 6) Cerro Acatlán, Veracruz, 7) Las Vigas, Veracruz, 8) Coatépec, Veracruz, 9) Xalapa, Veracruz, 10) Rio Metlác Drainage, Veracruz, 11) Pico Orizaba NP, Veracruz, 12) Tequila, Veracruz, 13) San Andrés Tenejapa, Veracruz, 14) Tlaquipa, Veracruz.

(Reprinted from Eitniear et al. 2000)

Effect of human disturbance on the estimated density of Chinese francolin (*Francolinus pintadeanus*) and Red junglefowl (*Gallus gallus*) in the dry forest of Southcentral Vietnam

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Introduction

The Red List IUCN 2015 indicates that 12 of the 22 Galliformes species are found in Southeast Asia are threatened (55%). Several of the non-threatened Galliformes species are considered to be tolerant of human disturbance, but data on this issue are currently limited, making their management potentially complicated and their future status unpredictable.

Recent surveys conducted in Yok Don National Park, the largest protected patch of Dry Dipterocarp forest in Southcentral Vietnam, showed a drastic decline in the resident Green Peafowl (*Pavo muticus*) population over the past 15 years due to human disturbance in the form of livestock grazing and understorey fires (Sukumal et al. 2015). This area also holds large populations of Chinese francolin (*Francolinus pintadeanus*) and Red junglefowl (*Gallus gallus*), two relatively abundant Galliformes species considered to be tolerant of human disturbance, and often found close to villages. They are both

categorized as Least Concern on the IUCN Red List (IUCN 2015). However, no specific investigations into their tolerance to disturbance have been yet conducted in the region.

Using data from Yok Don National Park, where threatened Galliformes species have shown a drastic decline, here we aim to: 1) estimate the density of these two species in what could be considered the largest remaining area of suitable habitat in southcentral of Vietnam, but with high disturbance levels (Sukumal et al. 2015); 2) investigate how various disturbance factors affect their density; and 3) draw preliminary conclusions on whether these species are actually tolerant to disturbance.

Figure 1: Chinese francolin using an unpaved road in Yok Don National Park

Methods

Study site

Yok Don National Park (12°47' -13°00' N, 107°29' -107°50' E) is located in Dak Lak Province, Southcentral Vietnam. The total area is 1155 km^2, making it the largest National Park in Vietnam. The area is dominated by dry dipterocarp forest (75% of total area) (Figure 2) on relatively flat terrain at 200-474m (Sterling et al. 2006).

Density estimation

The survey was conducted in January 2013 by establishing 15 line transects (each 2 km in length) in the south, central, and north sections of National Park separated by Yok Don Mountain in the south and Chu Minh Mountain in the north (Figure 2). Each transect was walked twice daily (at 06:00-08:00 and 16:15-18:15) by one observer for five consecutive days, giving 10 repeat surveys per transect. These times coincide with peaks of bird activity (Sukumal N. personal observation). During the survey each observer recorded all visual and auditory encounters with all Galliformes species by noting the number of birds, sighting distance, and sighting angle. The distance to each calling and seen bird was assigned within 50 m distance categories (see Sukumal et al. 2015 for details). Before data collection started, all observers conducted preliminary survey together to standardize estimates of distance to calling birds in order to minimize errors between observers (Buckland et al. 2001).

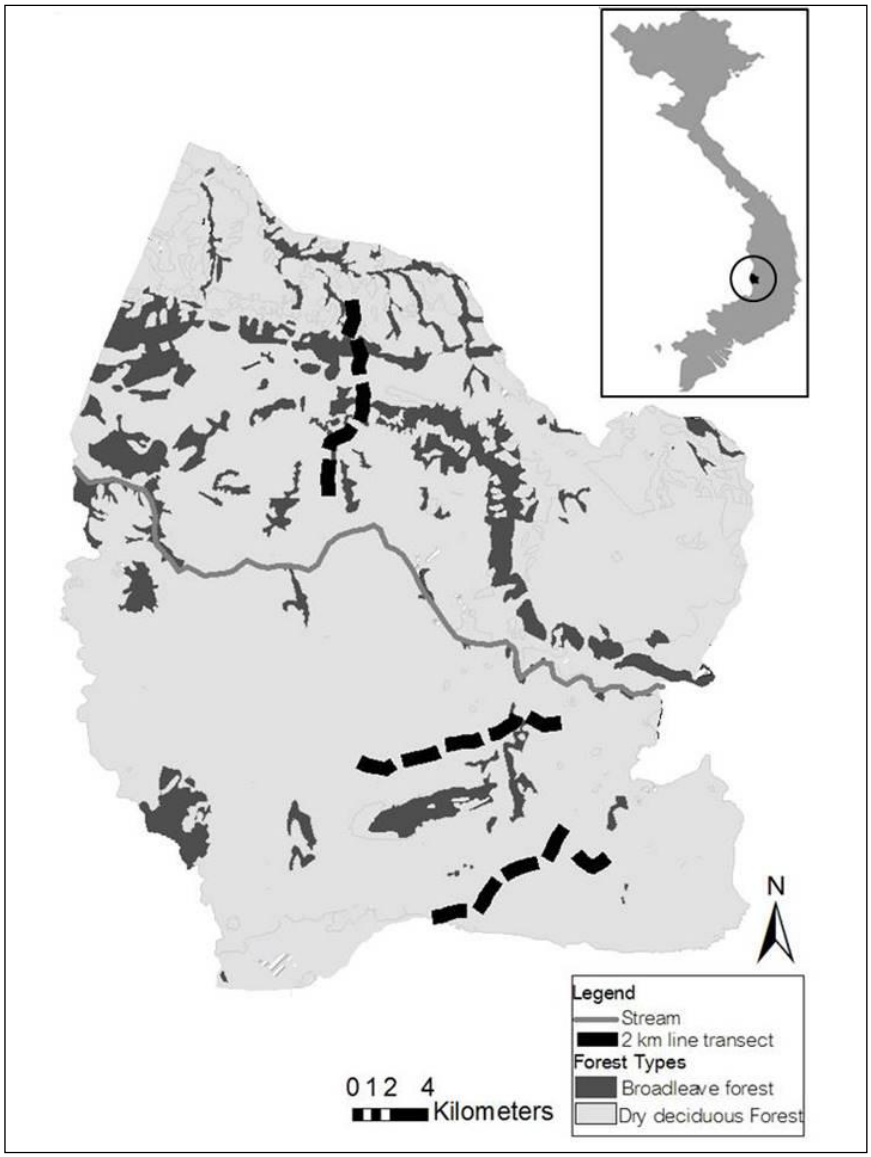

Figure 2: The location of the 15 line transects in the south, center and north parts of Yok Don National Park.

Density of both species was defined using DISTANCE version 6.0 (Thomas et al. 2010). Detections were entered as cluster objects and both aural and visual detections were analyzed. AIC was used to select the appropriate combination between the four commonly used detectability functions (uniform, half-normal, hazard-rate and negative exponential) and adjustments (cosine terms, Hermite or simple polynomials) (Buckland et al. 2001).

Habitat variables and human disturbances
We examined the influence of environmental variables on habitat use by the two species. We recorded habitat variables and human disturbances along each transect consisting of (1) ground vegetation coverage (absent, low and high) every 100 m along each transect, (2) presence of domesticated cattle or buffalo (present or absent) at every 100 m along each transect, (3) distance to permanent human settlement, and (4) distance to the forest edge, and water sources (using ArcGIS 9.3).

Habitat selection models
We assessed habitat use of the birds using Generalized Linear Mixed Models (GLMM) in R program using R- package lme4 (Bolker et al. 2011). The response variable (number of

calling and seen birds) was over-dispersed (ratio of variance to mean = 5.319 and 4.516 for Chinese francolin and Red junglefowl respectively) hence negative binomial was most appropriate for these data. In each model, day was treated as a random component for repeated surveys on each transect (Zuur et al. 2009). Continuous predictor variables of distance to permanent human settlement and distance to forest edge were standardized by dividing the values by twice the standard deviation (Gelman 2008) in order to transform the data to the same scale.

Results

Density estimation

We recorded a total of 411 detections: 270 for Chinese francolin and 141 for Red junglefowl. The overall density estimate for Chinese francolin was 2.95 birds/km^2, with the lowest density in the south section (Table 1). The density estimate for Red junglefowl was lower, at 1.53 birds/km^2, again with the lowest density in the south section (Table 1).

Habitat use and effect of human activity

The habitat selection models indicated that distance to the forest edge and presence of cattle correlated significantly with the estimated densities of both species (Table 2). The beta coefficient for distance to the forest edge was positive, suggesting that the number of birds detected was reduced close to the forest edge, while the beta coefficient for the presence of cattle was negative, suggesting that birds avoided cattle (Table 2).

Figure 3: (a) Burned and unburned understory of dry forest; (b) livestock freely grazing in dry forest.

Discussion

We report density estimates for both Chinese francolin and Red junglefowl in a large but disturbed area of dry dipterocarp forest in Southeast Asia. Unfortunately there are no comparable estimates in the region, so we cannot comment directly on how typical these levels may be. Overall, these densities are higher than that reported for the larger Green peafowl (0.25 birds per km^2: Sukumal et al. 2015), a species found to be abundant in agricultural areas in the region, provided there is low hunting pressure (Sukumal N. unpublished data). Given the decline of Green peafowl population at this site over the past 15 years, but not at the less disturbed Huai Kha Khaeng Wildlife Sanctuary in Thailand (Sukumal et al. *in review*), we can probably assume that human disturbance, including hunting, is relatively high at Yok Don. This is also the likely cause of an almost complete absence of large vertebrate species in the forest and suggests that the densities we obtained for francolin and junglefowl are also relatively low. Concerning the tolerance to human disturbance by the two study species, our results suggest that both species avoid human contact, here measured as proximity to the park

boundary, and presence of grazing livestock. Density is significantly reduced when close to the boundary and when lifestock was detected on the transects.
In conclusion, these preliminary results do not confirm the widely-held view that both Chinese francolin and Red junglefowl are tolerant to human disturbance, but we emphasise that similar quantitative data on pristine populations in the same dry habitat are not yet available. Moreover, we suggest that their populations in this area are relatively low, probably indicating past decline. The need for conservation action should not therefore be underestimated, as already suggested by Brickle et al. (2008).

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Table 1. Density estimates for Chinese francolin and Red junglefowl in Yok Don National Park.

Sections	Density estimates (number/km^2)	95% confidence intervals	Number detected
South			
Chinese francolin	1.33	1.06-1.67	45
Red junglefowl	0.58	0.36-0.94	14
Center			
Chinese francolin	3.26	1.51-7.00	69
Red junglefowl	1.56	0.69-3.52	41
North			
Chinese francolin	4.27	3.54-5.15	156
Red junglefowl	2.44	1.99-3.00	86
Total (pooled estimates)			
Chinese francolin	2.95	0.86-10.10	270
Red junglefowl	1.53	0.35-6.66	141

Table 2 Valuess of parameters in final models relating density to disturbance factors.

Parameters	Estimate	SE	Lower 95% CI	Upper 95%CI
Chinese francolin				
Distance to forest edge	0.77	0.27	0.25	1.30
Presence of cattle	-0.62	0.32	-1.31	0.02
Red junglefowl				
Distance to forest edge	1.05	0.37	0.33	1.80
Presence of cattle	-0.99	0.46	-1.93	-0.11
Ground vegetation coverage	0.16	0.40	-0.63	0.96