

Occurrence and population of Pied Lapwing *Vanellus cayanus* in São Paulo, south-east Brazil

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Received 11 March 2022; final revision accepted 20 February 2023

Cotinga 45 (2023): 34–42

published online 6 July 2023

A batuira-de-esporão *Vanellus cayanus* possui uma ampla distribuição ao longo dos rios e áreas alagadas da América do Sul, mas ainda existem lacunas geográficas e populacionais, sendo uma espécie ameaçada de extinção no estado de São Paulo, sudeste do Brasil. Com o objetivo de contribuir com a sua conservação neste estado, organizamos os dados de ocorrência geográfica dos últimos 200 anos, realizamos inventários de campo ao longo de nove anos e censos populacionais em dois rios da região oeste do estado de São Paulo. Entre 1818 e 2022 foram obtidos 39 registros para 29 localidades, que mostram uma ocorrência ampla, mas de aves vagantes no leste, e aves residentes em apenas duas localidades do extremo oeste do estado, os rios Aguapeí e do Peixe. Entre 2010 e 2019 foram feitos 18 registros de campo nestes rios, incluindo o primeiro relato de reprodução para São Paulo. Em 2020 foram contadas 19 aves no rio Aguapeí, incluindo filhotes, sendo a principal localidade de ocorrência no estado de São Paulo. É preciso realizar novos inventários de campo para encontrar possíveis populações desconhecidas, censos populacionais, estudos sobre biologia básica e ampliar a proteção legal dos rios Aguapeí e do Peixe, que abrigam outras espécies de aves ameaçadas em São Paulo.

Pied Lapwing *Vanellus cayanus* occurs across much of South America from Colombia, Venezuela and Guyana, south to Peru, Bolivia, Paraguay and north-east Argentina²³. The species occurs alone, in pairs or small family groups throughout most of Brazil, except the far south and parts of the coast²². It is a species typical of riverbanks and lake edges in the interior of the country, where it nests on sandbars^{22,23}.

V. cayanus was first reported in the state of São Paulo, south-east Brazil, in 1818, when the Austrian naturalist Johann Natterer (1787–1843) collected specimens in the municipality of Taubaté, in the rio Paraíba do Sul Valley. Natterer also collected it in the municipality of Itararé in 1821 and along the rio Grande in 1823¹⁶. Most historical records are associated with the main rivers in the state's interior, such as the Grande, Tietê and Paraná, but there are a few for eastern São Paulo, in addition to Taubaté, e.g., one collected by Ricardo Krone (1861–1917) on the coastal plain in the municipality of Iguape in 1899²⁵. The species is considered Vulnerable in São Paulo due to habitat destruction caused by the construction of hydroelectric dams, in addition to sand extraction from beaches and loss of riparian forests, which causes silting and pollution of rivers. Breeding by *V. cayanus* has yet to be documented in the state^{4,21,25}.

The lack of population data for *V. cayanus* in São Paulo precludes a more accurate assessment of its conservation status in the state²³, which is currently based on the literature⁴ and has yet to be addressed by field data. Therefore, we compiled historical and contemporary data on the species'

occurrence in São Paulo over the last 200 years, undertook a field survey over nine years, and performed population censuses along two rivers in the west of the state.

Methods

Secondary data.—Data concerning historical and contemporary occurrences were obtained from the scientific and grey literature, books, and the collection of the Museu de Zoologia da Universidade de São Paulo (MZUSP), the most representative collection of birds from the state. The online repositories WikiAves (<http://www.wikiaves.com.br>), eBird (<http://www.ebird.org>), Xeno-canto (<http://www.xeno-canto.org>) and iNaturalist (<http://www.inaturalist.org>) were also consulted (up to 10 March 2022), although the last two did not contain records. Records without specific localities were assigned to the central point of the relevant municipality.

Records were organised into 'historical' and 'contemporary', with the former covering the period 1818–1989 (mostly museum data) and the latter from the 1990s onwards. Four records attributed to scientific collections by Willis & Oniki²⁵ from Itapura, Pederneiras, Piracicaba and Nova Independência lack dates, but were considered historic following the references cited. Some historical locations presented in the last review of the species' status in São Paulo⁴ had their locations corrected, which generated small differences between the maps.

Field data.—Our study region was on the left bank of the rio Paraná, in western São Paulo, within the region bounded by 21°00'35.89"S

51°44'14.51"W; 21°15'59.53"S 51°11'25.54"W; 21°34'23.41"S 52°01'5.58"W; and 21°46'23.27"S 51°30'53.29"W. It covered the middle and lower rios Aguapeí and Peixe, including the state parks Rio do Aguapeí (PEA; 9,043.97 ha), created in 1998, and Rio do Peixe (PERP; 7,720 ha), established in 2002, in addition to a stretch of the rio Paraná (Fig. 1). This region of São Paulo has the lowest percentage cover of native vegetation due to deforestation during the colonial period⁷. In the study area the original vegetation is principally riparian forest²⁰ (Fig. 2). Climate is tropical, hot and humid, with summer rains and a dry season (winter) of 1–2 months. Mean annual precipitation is 1,250 mm, with an average 200 mm in January and 25 mm in July¹⁴.

Data were collected via field inventories and population censuses. Field surveys were carried out between 2010 and 2019 by PM (occasionally with DW), during a faunal inventory by the NGO Apena. Four trips were made per year, totalling 36 visits, 17 covering the rios Aguapeí and Peixe, especially inside the PEA and PERP. Observations were made from a motorboat or canoe using binoculars and cameras.

We performed censuses of the lower rios Aguapeí and Peixe, travelling by motorboat at a constant speed⁵. Counts were made only when travelling upriver, but the region's avifauna was sampled throughout the day. The first survey was conducted on 16 October 2020 on the rio Peixe. A total of 13 km (26 km round trip) was covered, with the count starting at 07h00 at the river's confluence with the rio Paraná, and ending at 09h30 c. 7.5 km (or 4 km straight line) inside the PERP, with a total of nine hours spent in the field that day (Fig. 1a,b). The second survey was on 19 October 2020 and covered the rio Aguapeí, in a Área de Preservação Permanente (APP) owned by the Companhia Energética de São Paulo. A total of 26 km (52 km round trip) was covered, with the count commencing at 07h00 at the river's mouth in the rio Paraná, and ending at 11h00 c. 7.3 km (or 3.7 km straight line) from the western edge of the PEA; seven hours were spent in the field (Fig. 1a,b). Complete lists of birds recorded during these surveys are available on eBird (S75394268 and S75408085).

Results

Literature review.—Thirty-nine literature records of *V. cayanus* in the state of São Paulo between 1818 and 2022 were located. Of this total, 14 are historical (specimens and one field observation) and 25 are contemporary. Of the latter, seven are from the literature (three published and four grey literature) and 18 from online platforms (15 from WikiAves alone, one only on eBird, and two on both). The data represent 29 locations, 12 in

the west of the state, 12 in the centre and five in the east. Only nine of these have more than one record; of these, only the rios Aguapeí and Peixe have records from multiple years, both historical and contemporary. Of the available records, 20 were on the banks of rivers, one at a pond and four at artificial waterbodies such as sewage treatment plants (Fig. 1, Table 1).

Field inventory.—Eighteen records of *V. cayanus* were on the rios Aguapeí and Peixe over 17 days in the field between 2010 and 2019. There were 15 records for the Aguapeí, with 13 in the PEA and two on the lower part of the river, outside the park. There were three records on the rio Peixe, with two in the PERP and one at its border. We observed singles, possible pairs, and trios, on beaches of various sizes and throughout the year (Appendix). On 16 September 2017, a pair had a nest with two eggs on a beach in the PEA, which was the only breeding record during this visit. The nest was a shallow depression within which the pair concealed their eggs in the sand (Fig. 3).

Population census.—We did not detect the species during surveys of 13 km of the rio Peixe, but we observed 108 bird species, including two taxa treated as Endangered in the state: Yellow-billed Tern *Sternula superciliaris* ($n = 3$ individuals) and Large-billed Tern *Phaetusa simplex* ($n = 24$). On the rio Aguapeí we saw 19 *V. cayanus*, 17 adults and two juveniles. Five possible pairs were seen, each on a different beach, as well as two trios on two other beaches, and a pair with two small chicks on another (Fig. 4). The trios and pair with chicks were on larger beaches, but the species' absence from many beaches of different sizes was also noted. A total of 85 bird species was recorded on the rio Aguapeí, including six taxa threatened with extinction in São Paulo: *Sternula superciliaris* ($n = 1$), *Phaetusa simplex* ($n = 1$), Red-billed Scythebill *Campylorhamphus trochilirostris* ($n = 1$), Black-fronted Nunbird *Monasa nigrifrons* ($n = 2$), Swallow-winged Puffbird *Chelidoptera tenebrosa* ($n = 1$) and Chestnut-eared Aracari *Pteroglossus castanotis* ($n = 2$).

Discussion

The literature review doubled the known number of locations for *V. cayanus* in the state of São Paulo presented in the last revision⁴, from 14 to 29. However, it also revealed the small number of studies that report the species, just two papers^{10,13} and three grey literature references^{2,12,15}. The most significant contribution of our review is the addition of 17 records from online platforms, which now represent the largest dataset on the species' occurrence in São Paulo. The large number of records on WikiAves (17) is presumably because it has been the main ornithological platform in Brazil since its creation in 2008²⁴; eBird has been

used with greater frequency in recent years. These, and other platforms, likely will contribute further records in the future.

V. cayanus is widely distributed in São Paulo, but occurrences can be separated into two main categories. The first includes records of lone individuals in the east (municipalities of Taubaté, Iguape, Itanhaém, Sete Barras and Ubatuba) during November–January (plus one in September), the species' non-breeding period, suggesting they were vagrants. The second involves records in the far west, concentrated along the rios Aguapeí and Peixe; the number of records and year-round presence suggest the species is resident there. Records from the centre of the state need further study to determine the species' status there. Despite the wide geographical distribution, the species was recorded in just five protected areas (Estação Ecológica Jataí, Estação Experimental Luiz Antônio, Estação Experimental Itirapina, Parque Estadual Aguapeí and Parque Estadual Rio do Peixe) and is resident in only the last two. Another factor of concern is that of 11 localities with historical records—five of them in the centre-west—only one (Nova Independência, rio Aguapeí) has modern records (Fig. 1, Table 1).

These localities were not revisited in the present study, which is an important future action.

The presence of *V. cayanus* along the middle and lower rios Aguapeí and Peixe, as well as around Presidente Epitácio, is known by a few historical occurrences²⁵, records on online platforms^{8,24} and from observations by the managers of two protected areas (N. Gallo pers. obs.). However, our surveys between 2010 and 2019 expanded knowledge of the species on both rivers, producing a more accurate map of records (larger distribution, more individuals, and new natural history data), and showed that it occurs both inside and outside the protected areas (Fig. 1, Appendix). The first breeding record in São Paulo was made during our survey. Although Willis & Oniki²⁵ suggested the species might nest in the state, its breeding ecology in Brazil remains little known^{3,10}. The nest we found is similar to previous descriptions, and the behaviour of covering the eggs to protect them from predators is also known^{3,11} (Fig. 3). Our field data, together with information from WikiAves and eBird, show that in São Paulo currently only the Aguapeí and Peixe have resident populations—with evidence of nesting in the former area—making them priorities for conservation.

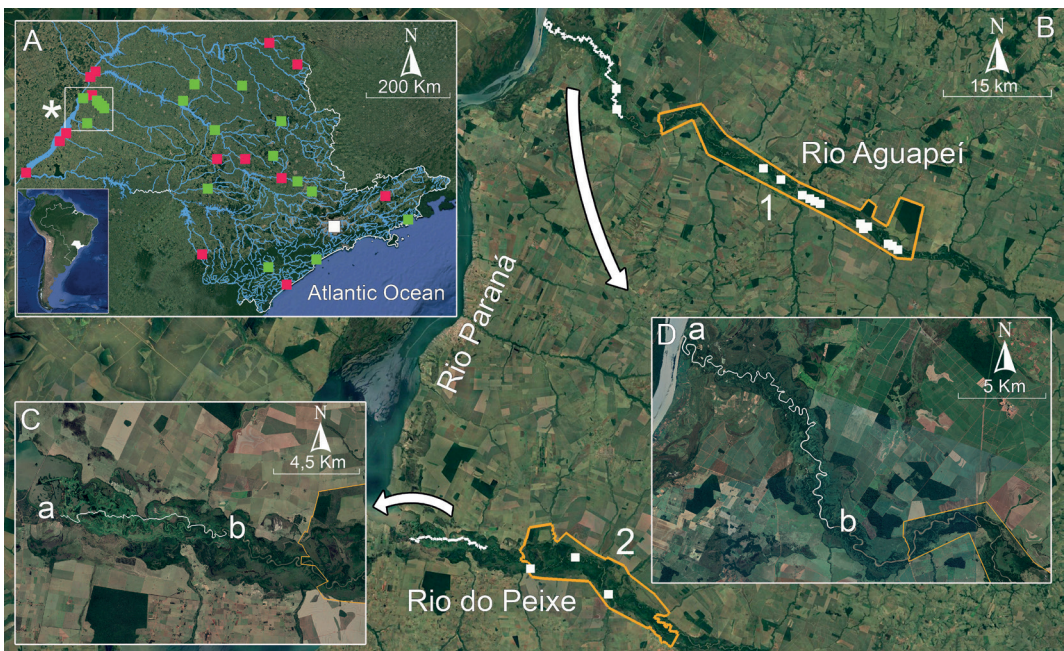


Figure 1. Records of Pied Lapwing *Vanellus cayanus*. A: São Paulo state. White square = city of São Paulo (capital); red squares = historical records; green squares = contemporary records (Table 1). The white box next to the asterisk indicates the study area in western São Paulo (B); B: 1. Aguapeí State Park and 2. Rio do Peixe State Park, with their boundaries in orange. The white dots indicate records made during the field survey (see Table 1); C: Rio do Peixe study area; D: Rio Aguapeí study area. The white stretches of each river during the survey transects made from their mouths (a) to the vicinity of the parks (b). Source: Google Earth (Landsat/Copernicus 2020).



Figure 2. Rio Aguapeí, São Paulo state, Brazil, showing some of the beaches where Pied Lapwing *Vanellus cayanus* occurs (Peter Mix)

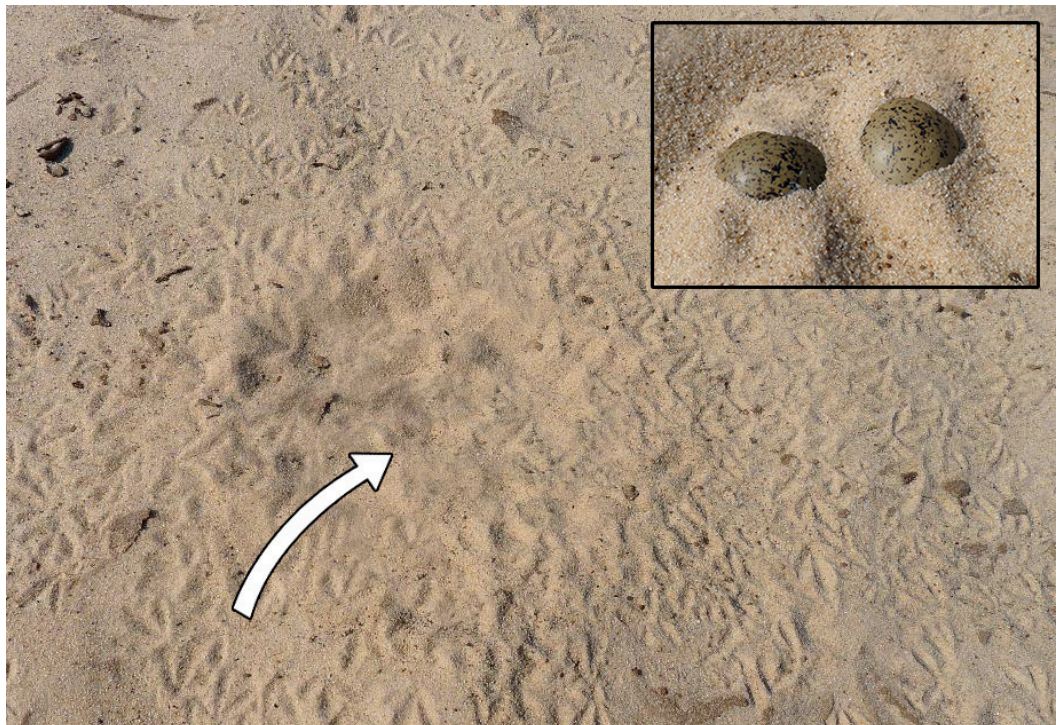


Figure 3. Nest of Pied Lapwing *Vanellus cayanus* on the rio Aguapeí, São Paulo state, Brazil; the white arrow indicates the site of the nest, with the eggs partially covered by the birds highlighted upper right (Peter Mix)

Table 1. Historical and modern data on the occurrence of Pied Lapwing *Vanellus cayanus* in the state of São Paulo, Brazil. Acronyms in the Record type and Source columns are: C (collected), O (observation), P (photographed), WA (WikiAves), S (eBird).

No.	Region	Municipality, locality	Coordinates	Date/period	Record type	Collector / Observer	Source
1	East	Taubaté, Taubaté	23°02'S	24–25 Nov 1818	C	J. Natterer	16
1a		Taubaté, Bairro Independência	45°35'W	not known	C	–	25
2	Central	Itararé, undetermined	24°07'S 49°20'W	Jan 1821	C	J. Natterer	16,25
3	Central	Miguelópolis, Rio Grande, Porto do Rio Paraná	20°07'S 47°56'W	Apr–May 1823	C	J. Natterer	16,25
4	East	Iguape, rio Iguape	24°42'S 47°33'W	Jan 1899	C	R. Krone	17,25
5	Central	Franca, Indaya	20°32'S 47°24'W	Jul 1903	C	O. Dreher	17
6	West	Itapura, Faz. Itapura	20°39'S	Oct 1904	C	E. Garbe	17
6a			51°30'W	–	C	–	25
7	West	Presidente Epitácio, not stated	21°46'S 52°06'W	June 1926	C	J. Lima	17
7a		Presidente Epitácio, not stated	21°51'S 52°16'W	Aug 1935	C	J. Lima	17
8	West	Rosana, Balsa	22°32'S 53°00'W	13 Jul 1989	O	E. O. Willis	25
9	Central	Jaú, Pederneiras, rib. Boca	22°20'S 48°43'W	–	C	–	25
10	Central	Piracicaba, ESALQ	22°42'S 47°38'W	–	C	–	25
11	West	Nova Independência, not stated	21°06'S	–	C	–	25
11a			51°29'W	19 Feb 2012	P	A. L. Briso	WA576299
12	Central	Luiz Antônio, Estação Ecológica Jataí/Estação Experimental de Luiz Antônio	21°37'03"S 47°45'55"W	Jul 1999–Mar 2002	O	–	1
13	Central	Americana, Município de Americana	22°44'59.99"S 47°20'56.68"W	–	O	–	2
14	Central	Itirapina-Brotas, Estação Ecológica de Itirapina	22°13'06.75"S 47°53'53.03"W	between 1998 and 2007	O	–	13
15	West	Dracena, PE do Rio do Peixe	21°36'23.16"S	19 May 2006	P	G. Malacco	WA167879, S33599748
15a			51°42'9.86"W	14 Apr 2017	P	N. T. Meira	WA2528357
16	Central	Campinas, Fazenda Santa Elisa	22°54'20"S 47°05'34"W	Oct 2006–Jun 2007	O	–	15
17	West	Monte Castelo, rio Aguapeí (PE Aguapeí)	21°11'37.79"S 51°32'39.24"W	20 Mar 2007	P	N. Gallo	WA1351291
18	East	Itanhaém, rio Preto	24°10'41.35"S 46°56'49.21"W	6 Sep 2008	O	–	10

No.	Region	Municipality, locality	Coordinates	Date/period	Record type	Collector / Observer	Source
19	East	Sete Barras, rio Ribeira de Iguape	24°23'33.15"S 47°55'37.79"W	28 Dec 2008	P	F. Guglielmino	WA127585
20	Central	Bebedouro, Córrego Mandembo	20°56'0.54"S 48°29'30.14"W	7 Mar 2009	O	B. Lima	¹⁰
20a		Bebedouro, Estação de tratamento de esgoto		27 Mar 2010	P	M. Stamato	WA123460
21	West	Mirandópolis, rio Aguapeí	21°18'56.79"S 51°17'15.26"W	7 and 31 Jul 2010	P	M. Olyntho	WA182367
22	West	Ubarana, afluente do rio Tietê	21°14'43.23"S 49°43'25.91"W	26 Mar 2011	P	C. Malavazi	WA319371
23	West	Irapuru, rio Aguapeí	21°18'13.65"S 51°18'30.47"W	22 Nov 2012	P	E. Luiz	WA813839
23a				29 Apr 2021	P	W. Alves	WA4292216
24	West	Junqueirópolis, rio Aguapeí	21°15'18.61"S 51°25'44.89"W	22 Nov 2012	P	A. Cintra	WA814980
24a				25 Sep 2013	P	multiple	WA1107030
25	Central	Ibitinga, Vila de Cambaratiba (rio Tietê)	21°46'7.99"S 49°02'26.56"W	29 Dec 2013	P	Breno FT	WA1197812
26	West	Paulicéia, APP Foz do Aguapeí	21°06'15.70"S 51°44'23.37"W	Feb–Mar 2012 or 2013; Aug–Sep 2012	O	E. E. Myiaji	¹²
27	East	Ubatuba, foz do rio Indaiá, praia Perequê-Açu	23°24'58.64"S 45° 3'13.48"W	11 Dec 2014	P	multiple	WA1587882
28	Central	Águas de Santa Bárbara	22°52'54.00"S 49°14'33.36"W	1 Jan 2016	P	C. Ferreira	WA2009565
29				25 Nov 2018	P	multiple	WA3312746
29a	West	Bady Bassit, Estação de Tratamento de Esgoto	20°55'35.7"S 49°29'31.1"W	15 and 24 Mar 2019	P	multiple	WA3259236, S53907426
29b				19 Dec 2020	P	multiple	WA4754554, S77660857

Our population censuses reflected the same scenario observed during other surveys, that *V. cayanus* is more common along the rio Aguapeí. This may be directly related to the location of this and the rio Peixe in relation to the Porto Primavera hydroelectric dam, further south on the rio Paraná. The mouth of the rio Peixe is c.145 km from Porto Primavera, and its lower reaches have lost many beaches due to the increase in water level caused by the dam. The mouth of the rio Aguapeí is c.200 km from the dam and c.55 km north of the rio Peixe, and has maintained most of its beaches. This needs to be further investigated with further field surveys, as does the presence of the species on other rivers in western São Paulo, including the rio Paraná and its islands, as well as its tributaries in the state of Mato Grosso do Sul, such as the Verde and Pardo.

Chicks observed during the October survey, together with the nest in September, show that the breeding period of *V. cayanus* extends beyond May and August^{3,23}, when river levels are low and more beaches are exposed. Field data, together with the

literature¹⁰ and images available online²⁴ show that the species also breeds in September–November. This issue requires further exploration with fresh field work.

Conservation

These surveys enabled us to develop a database that could support analyses of population variation in these two regions based on future counts and partially meet the need for population data for *V. cayanus*⁴. This information is essential to assess the species' threat status in São Paulo, thereby supporting various conservation actions^{6,21}.

V. cayanus was considered Vulnerable in the first list of threatened fauna in São Paulo¹⁸. Its status was changed to Critically Endangered in 2008¹⁹ then downlisted to Vulnerable in 2018²¹. We suggest *V. cayanus* should be categorised as Endangered in São Paulo following IUCN criterion B2a,b(iii) because populations are known only along the rios Aguapeí and Peixe, including unprotected stretches (fewer than five locations; see IUCN⁹). We estimate its area of occupancy to be smaller



Figure 4. Adult and chick Pied Lapwing *Vanellus cayanus* recorded on different beaches of the lower rio Aguapeí, São Paulo state, Brazil (Fabio Schunck)

than 500 km², considering only those beaches of these two rivers actually or potentially occupied by the species.

It is necessary to invest in field surveys of the main rivers and their tributaries in centre-west São Paulo, including those with historical records but none in the modern era. Monthly or twice-yearly surveys of the rios Aguapeí and Peixe are also desirable, one each in the breeding and non-breeding periods, as well as of other rivers that could support resident populations. These could provide data for other threatened species as well, such as the Critically Endangered Bare-faced Curassow *Crax fasciolata*. Basic studies of *V. cayanus*, including monitoring family groups via ringing or GPS marking, to generate data on breeding, ecology and possible seasonal movements (which are still unknown), should also be encouraged.

Actions that can contribute to *V. cayanus* conservation, as well as that of other threatened bird species in western São Paulo, include: expansion of legal protection along the rios Aguapeí and Peixe, including regions downstream and upstream of existing protected areas; implementation of the Plano Operacional de Conectividade (Operational Connectivity Plan), whose main objective is to promote connectivity among protected areas in the Corredor de Biodiversidade do Rio Paraná (River Paraná Biodiversity Corridor); monitor, organise and guide leisure activities by fishermen and others on the region's rivers; and employ technical data to manage and monitor existing protected areas, in addition to environmental awareness activities involving local communities including their children and youth.

Acknowledgements

We thank the following: Companhia Energética de São Paulo, especially André Rocha and José Dimas Aléssio, for authorising access to the APP do Rio do Peixe and Foz do Aguapeí; the pilots Luís, Antonio Damiano and José Aparecido for their assistance in the field; the Apoena team for supporting surveys in western São Paulo, in particular Cristine Chiarello Weffort and Genildo Roberto de Oliveira; Nelson Gallo, Jeferson Bolzan and Natalia Poiani from the São Paulo Forestry Foundation for their support; Luis Roberto Gomes, Nelson Bugalho and Otávio Marinho for supporting the work of Apoena; Luís Fábio Silveira (MZUSP), Cláudia Oliveira, Michelângelo Stamato and Cecilia Malavazi for data from various sources and regions; Vagner Cavarzere and an anonymous referee for their comments on the manuscript; and Paulo Rogerio for finalising the map.

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Appendix. Pied Lapwing *Vanellus cayanus* occurrence data from field inventories between 2010 and 2019 on the rios Aguapeí and Peixe, São Paulo state, Brazil. Activity (Act.): F (foraging), Y (flying), L (landing), B (breeding).

Locality	Date	Time	Coordinates	Act.	No. of birds	Observations
Rio Aguapeí, PEA, upper part	27 Apr 2010	15h10	21°17'06"S 51°23'07"W	F	2	Near the Poção
Rio Aguapeí, PEA, upper part	27 Apr 2010	16h30	21°15'04"S 51°25'07"W	F	3	Left bank
Rio Aguapeí, PEA, central part	28 Apr 2010	10h00	21°14'6.14"S 51°28'17"W	Y	2	Near Rodovia da Integração bridge
Rio Aguapeí, PEA, upper part	8 Nov 2010	11h15	21°16'36"S 51°24'08"W	F	2	Near mouth of Taquarussú
Rio Aguapeí, PEA, upper part	10 Nov 2010	10h00	21°16'34"S 51°23'08"W	F	1	Near the Poção
Rio Aguapeí, PEA, central part	18 Feb 2011	13h00	21°12'35"S 51°30'48"W	L	1	
Rio Aguapeí, low part	5 Oct 2011	07h30	21°08'42"S 51°41'24"W	L	1	APP Foz do Aguapeí
Rio Aguapeí, low part	6 Oct 2011	06h00	21°07'20"S 51°41'16"W	L	1	APP Foz do Aguapeí
Rio Aguapeí, PEA, central part	3 May 2012	06h00	21°14'11"S 51°28'53"W	F	2	
Rio Aguapeí, PEA, central part	4 May 2012	08h00	21°14'22"S 51°28'22"W	L	2	
Rio Aguapeí, PEA, central part	18 May 2013	07h00	21°11'46"S 51°31'51"W	L	1	
Rio Aguapeí, PEA, upper part	19 May 2013	10h30	21°15'55"S 51°25'23"W	F	2	
Rio Aguapeí, PEA, central part	7 Aug 2013	08h45	21°13'47"S 51°29'36"W	F	1	Near PEA headquarters
Rio Aguapeí, PEA, upper part	16 Sep 2017	09h00	21°15'24"S 51°25'27"W	B	2	Pair with nest (photograph)
Rio Aguapeí, PEA, central part	3 Aug 2019	07h30	21°14'06"S 51°28'45"W	Y	1	
Rio do Peixe, PERP, central part	17 Aug 2012	13h00	21°37'49"S 51°41'56"W	L	1	Above mouth of Ribeirão Claro
Rio do Peixe, low part	29 Sep 2012	11h00	21°36'13"S 51°46'50"W	L	1	South of Casa Amarela
Rio do Peixe, PERP, central part	29 Sep 2012	13h30	21°35'34"S 51°44'10"W	F	2	Near Lagoa do Berçário