J. Trop. Plant Pests Dis.
Vol. 26, No. 1, March 2026
Pages: 112–135

ISSN: 1411-7525
E-ISSN: 2461-0399
DOI : 10.23960/j.hptt.126112-135

RESEARCH PAPER

Distribution of *Diaphorina citri*, a citrus huanglongbing vector in Indonesia and new locality records

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Manuscript received: 26 December 2024. Revision accepted: 3 May 2025. Available online: 2 January 2026.

ABSTRACT

The Asiatic citrus psyllid (*Diaphorina citri*) is the primary vector of the destructive citrus disease huanglongbing (HLB), posing a significant threat to citrus production in Indonesia. Systematic surveys of *D. citri* are essential for identifying areas at high risk of HLB outbreaks and for supporting sustainable disease management. This study aimed to assess the population distribution of *D. citri* in major citrus-producing regions of Indonesia and to evaluate its potential risk for HLB spread. The research was conducted over two consecutive years (2022–2023) across key citrus production areas on the islands of Java, Sumatra, Kalimantan, and Bali. A total of 206 sampling sites were surveyed using direct manual inspection and two types of yellow traps. *D. citri* was detected at 35 locations, representing new country records. The distribution pattern was relatively uniform in Sumatra but more scattered in Java and Kalimantan, with the highest population densities observed in the lowland areas of Bengkulu. These findings provide critical insights into *D. citri* distribution patterns and support targeted surveillance and sustainable management strategies to mitigate the impact of HLB in Indonesia.

Keywords: *Diaphorina citri*, population distribution, huanglongbing, Indonesia

INTRODUCTION

The Asian citrus psyllid (*Diaphorina citri*), also known as ACP, is the primary vector of citrus greening disease, Huanglongbing (HLB). This disease poses a significant threat to global citrus agriculture (Berk, 2016; Snyder et al., 2022a; Urbaneja et al., 2020), particularly in Indonesia (Lestiyani et al., 2024; Marisna et al., 2024). It is imperative to comprehend the biology and distribution of ACP to effectively manage its impact, as ACP plays a crucial role in the dissemination of the bacterial agent responsible for HLB, *Candidatus liberibacter asiaticus* (CLas) (Ahmad et al., 2023; Ibanez et al., 2019; Kasinathan et al., 2021; Wang et al., 2020; Yang et al., 2021).

ACP populations exhibit a strong correlation with citrus plantations (Graham et al., 2024; Widyaningsih et al., 2017; Wu et al., 2024), underscoring the need for comprehensive surveillance in major citrus-producing regions such as East Java, North Sumatra, Bali, West Kalimantan, and South Kalimantan (Hakim & Wahyuningsih, 2020; Zamzami et al., 2021; Setyaningrum et al., 2025). These regions collectively contribute a substantial share of Indonesia's orange production. Effective management strategies prioritize reducing ACP vector density (Wu et al., 2024), which has been shown to correlate with decrease CLas transmission and reduced HLB disease expression (Grafton-Cardwell et al., 2013).

In Indonesia, HLB continues to present a substantial challenge for both agricultural producers and government entities (Foda et al., 2021; Himawan et al., 2011; Widyaningsih et al., 2019). However, detailed records documenting ACP distribution are limited and often lack precise geographic coordinates, thereby hindering effective pest control and monitoring efforts (Arry et al., 2017; CABI, 2012; Subandiyah et al., 2000; Zuhran et al., 2021). Evidence of ACP presence remains scant, with only a few reports documenting its detection, including a recent finding in Sambas, Kalimantan (Zuhran et al., 2021). Conversely, surveillance efforts in regions such as Central Java have not detected any ACP populations (Setyaningrum et al., 2023).

The dearth of reliable, location-specific data

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underscores the necessity for comprehensive surveys to accurately map current ACP populations. The primary objective of this research is to identify the current distribution and population status of ACP within Indonesia's major citrus-producing regions, with the aim of facilitating targeted HLB management. Addressing this knowledge gap will enable more effective pest population tracking, inform strategic control measures, and ultimately reduce the spread of HLB. This, in turn, will help safeguard Indonesia's citrus production and ensure industry sustainability.

MATERIALS AND METHODS

Research Site. The survey for this study was conducted over two consecutive years using various monitoring methods, including direct inspection, yellow sticky traps, and yellow cylinder traps, across several citrus-growing centers in Indonesia. The study encompassed the following provinces: Bali, Bengkulu, East Java, West Java, Central Java, West Kalimantan, and Yogyakarta. The research was carried out from early January 2022 to late December 2023.

Direct Manual Inspection. The direct manual inspection (DMI) method was carried out on citrus plants (*Citrus* spp. and *Murraya* spp.) by directly observing young shoots in a clockwise direction for one-min (60 s) intervals (Figure 1). During each observation, the number of ACP adults and nymphs (when present) was recorded. The location of each sampled plant was marked using a Global Positioning System (GPS) device to ensure accurate georeferencing.

Observations were conducted randomly on selected plants, particularly those bearing new shoots, which serve as preferred sites for ACP feeding and reproduction. DMI was performed by randomly selecting 10% of the total plant population on each farm. The results of direct observations were classified into two categories: low and high population levels. A high ACP population was defined as the presence of more than 30 (>30) adult and nymph individuals per single tree, whereas a low population was defined as 30 or fewer (≤30) individuals per citrus tree (Setyaningrum et al., 2025).

Yellow Sticky Traps. The yellow sticky traps (YSTs) used measured 20 × 25 cm and were coated with adhesive on one side (Figure 2). The traps were suspended using rope at a height of approximately 1.5 m above ground level and positioned at the edge of the citrus canopy. Depending on the region, the traps were left in the field for 3–7 days.

At the end of the trapping period, the YSTs were collected and covered with transparent plastic wrap to prevent adhesion between traps and to facilitate observation. Counting was conducted in the laboratory using a stereomicroscope, and the number of captured ACP individuals was recorded. YST deployment was conducted at a total of 24 locations across various citrus plantations in Indonesia, with up to seven trap replicates per observation site.

Yellow Cylinder Traps. The yellow cylinder trap (YCT), also known as the 3D-printed psyllid trap, is a three-dimensional ACP trap manufactured using a three-dimensional (3D) printer (Snyder, et al., 2022b). This trap was developed in mid-2002 by James Snyder of the Florida Department of Agriculture and Consumer Services, USA, and has demonstrated promising results in field evaluations conducted in Florida and California (Snyder, et al., 2022a). The trap deployment in the field is illustrated in Figure 3.

The design of the 3D-printed cylinder trap was based on specifications provided by Snyder (Snyder, et al., 2022b), while materials were adapted according to local availability. The YCT generally consists of a transparent dome, funnel, collecting vials, cylinder, and cap. The 100-mm clear dome was made from polyethylene terephthalate (PET) commercial clear

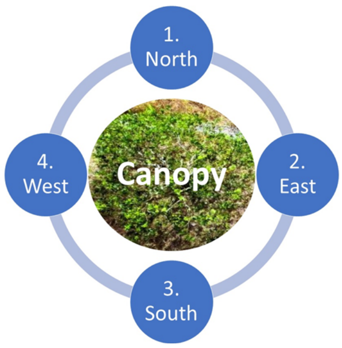

Figure 1. Layout direction for the manual inspection method used in the surveillance of *Diaphorina citri* on citrus trees.

cup lids obtained locally. The funnel, with a screw size of 76.2 mm (3 inches), was 3D printed in yellow polylactic acid (PLA) at the "Centi" print shop of Centra Teknologi Indonesia Inc. The funnel surface was smoothed using #1 sandpaper and coated with resin.

The collecting vial consisted of a 15-mL centrifuge tube (Labware Charuzu Inc.) that fit the diameter of the funnel tip. The cylinder was constructed from 3-inch polyvinyl chloride (PVC) tubing (Trillium Ltd) cut to a length of 100 mm. The PVC surface was painted with Diton Premium 9014 Fluorescent Yellow (Difan Prima Paint Inc.) using a layered technique to ensure uniform color distribution.

For trapping, the assembled YCT was suspended using wire at a height of approximately 1.5 m above ground level on the outer edge of the plant canopy. The centrifuge vial was filled with 5–6 mL of Yamalube (Yamaha Motor Co. Ltd) and installed inside the funnel at the top of the cylinder to preserve trapped ACP specimens for later collection. The YCTs were deployed for 3–7 days, depending on the location. Trapping using YCTs was conducted in triplicate at each observation site.

Sites and Data Collection. The survey locations were citrus-growing centers situated on the islands of Bali, Java, Sumatra, and Kalimantan. Sites were selected randomly in consultation with local agricultural extension officers. A total of 206 sites were surveyed, as illustrated in Figure 4. Results from YCT, YST, and direct inspections were tabulated for further analysis.

The data were classified into three categories: low population, high population, and no population. A low population was defined as the presence of 30 or fewer (≤30) adult ACP individuals per tree, whereas a high population was defined as the presence of more than 30 (>30) adult ACP individuals per tree. Sites where no ACP individuals were detected were classified as having no population.

Environmental data, including temperature and rainfall (precipitation), were obtained from the Indonesian Meteorology, Climatology, and Geophysical Agency (BMKG) and compiled on a monthly basis to evaluate differences in environmental conditions across observation areas. Location data were recorded using a Garmin GPSMAP 64s device (Garmin Inc.) in Universal Transverse Mercator (UTM) format, including elevation at each observation site. The GPS-derived coordinates were subsequently verified using Google Earth to ensure positional accuracy in cases of potential GPS deviation.

RESULTS AND DISCUSSION

Table 1 presents a summary of ACP monitoring results across various locations. The summary includes the trapping methods used at each site (DMI, YST, and YCT) along with the resulting ACP population status. It should be noted that not all locations were

Figure 2. Yellow sticky trap (YST) installed in a citrus tree during the survey.

Figure 3. Yellow cylinder trap in the field during surveillance.

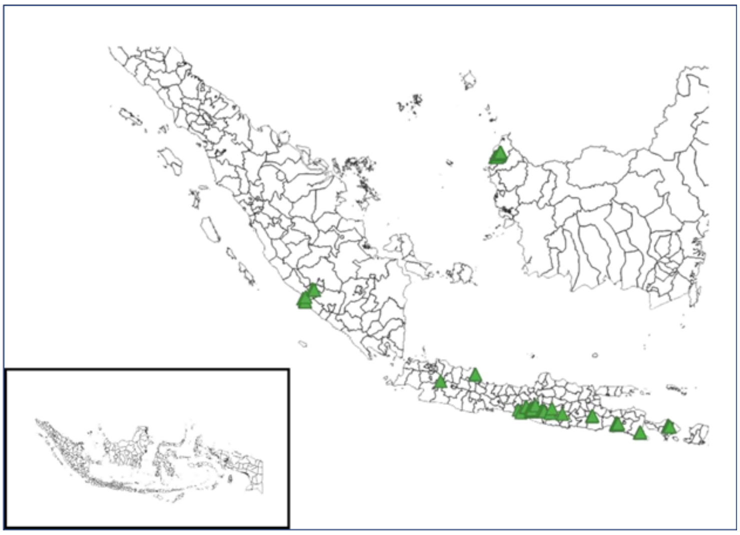

Figure 4. Map of the 206 sites used for the monitoring *Diaphorina citri* in Indonesia during 2022–2023.

subjected to all trapping methods due to technical or environmental constraints. The following sections provide a detailed discussion of the results obtained from each monitoring method.

Surveys were conducted using three approaches: direct manual inspection, YST, and YCT. A total of 206 sites were visited and verified for the presence or absence of ACP populations. All observation sites, including their geographic coordinates (longitude, latitude) and ACP population status, are presented in Table 1. Of the 206 sites surveyed, 83 were located in Kalimantan, 79 in Java, 26 in Sumatra, and 18 in Bali. Direct manual inspection was performed at all sites, whereas YST and YCT were deployed at 24 and nine sites, respectively. Based on the survey results, ACP populations were categorized into three groups: absent, low, and high. Across all sites, ACP populations were high at three locations, low at 32 locations, and absent at 171 locations.

Direct Manual Inspection. Direct manual inspection conducted at 206 sites confirmed the presence of ACP populations at 35 locations (Table 2). These sites were further categorized based on population density into those with ≤30 ACP individuals per citrus tree and those with >30 individuals per tree. The confirmed ACP populations were geographically dispersed, with most sites located in Bengkulu (12 sites), Java (19 sites), and West Kalimantan (4 sites). These locations represented diverse agroecological conditions, ranging from highland areas in Bengkulu (102.493, −3.3773; 949 m above sea level) to lowland regions such as Banyuwangi, East Java (114.27, −8.5371; 111 m above sea level).

Yellow Sticky Traps. YST are among the most widely used tools for monitoring ACP populations. Table 3 summarizes the results obtained using the YST method. Of the 24 sampling sites where YSTs were deployed in East Java, Central Java, Bengkulu, and West Kalimantan, ACP populations were detected at 11 sites. Most detections occurred in Bengkulu (six sites), followed by West Kalimantan (four sites) and East Java (one site).

The observation sites in Bengkulu encompassed both lowland and highland environments. Four sites (UTM 102.32, −3.9058; 102.322, −3.9041; 102.322, −3.9043; and 102.322, −3.9042) were located in lowland area, while two sites (UTM 102.493, −3.3773 and 102.497, −3.3791) were situated in highland areas. In contrast, sites in Java were relatively uniform in elevation. Meanwhile, several sites in West Kalimantan were located at or slightly below sea level, indicating distinct environmental conditions compared with other regions.

Yellow Cylinder Traps. YCT are a relatively new method for monitoring ACP populations but have shown promise in detecting ACP presence. In this study, YCTs were deployed at nine selected sites. ACP populations were detected at two sites: one in Central Java and one in East Java (Table 4). No ACP populations were detected at YCT sites in West Kalimantan. The environmental conditions of the confirmed sites differed markedly, with the East Java site (114.27, −8.5371) located in a lowland area and the Central Java site (110.204, −7.6087) situated in a highland region. These differences suggest that local environmental factors, including temperature, may influence ACP presence.

Table 1. Summary of surveillance results on the population status of *D. citri* in Indonesia, 2022–2023

Site no.	Longitude	Latitude	Province	Code	Inspection method*	ACP population**	Number of observed plants
1	102.251	-3.78786	Bengkulu	BENTENG	1	-	10
2	102.3102	-3.86601	Bengkulu	KAMPBÁPTÍS	1	-	10
3	102.3188	-3.90587	Bengkulu	BO4	1	+	5
4	102.3188	-3.90584	Bengkulu	LPKASLAMÆ	1	-	10
5	102.32	-3.90575	Bengkulu	BO5RUSAK	1, 2	+	5
6	102.3216	-3.90406	Bengkulu	BO1	1, 2	+++	5
7	102.3217	-3.90427	Bengkulu	BO2	1, 2	+++	5
8	102.3219	-3.90421	Bengkulu	BO3	1, 2	+++	5
9	102.3247	-3.90401	Bengkulu	OSS	1	-	10
10	102.3258	-3.90171	Bengkulu	DJEMADIPUSAT	1	-	10
11	102.3263	-3.90234	Bengkulu	DJEMADI2	1	+	10
12	102.3308	-3.90649	Bengkulu	DJEMÁDI3	1	+	10
13	102.3454	-3.73498	Bengkulu	011	1	-	10
14	102.3454	-3.73498	Bengkulu	JOHÁN	1	-	10
15	102.4717	-3.36177	Bengkulu	HÁBIBÆDAUD2	1	-	10
16	102.4746	-3.36136	Bengkulu	HÁBIBÆDAUD	1	+	10
17	102.4927	-3.37732	Bengkulu	NORMAN	1, 2	+	10
18	102.4934	-3.37707	Bengkulu	NOR1	1	+	10
19	102.4964	-3.37905	Bengkulu	DARLIS	1	+	10
20	102.4966	-3.3791	Bengkulu	DETRO	1, 2	+	10
21	102.5846	-3.44998	Bengkulu	010	1	-	10
22	102.6361	-3.48956	Bengkulu	DENI	1	-	10
23	102.6377	-3.48829	Bengkulu	MEIDI	1	-	10
24	102.6418	-3.48677	Bengkulu	MARKUS	1	-	10
25	102.6466	-3.48546	Bengkulu	LBAWÁNG	1	-	10
26	102.6491	-3.48518	Bengkulu	MEIDÍ2	1	-	10
27	107.1536	-6.69873	West Java	MAJALAYA3	1	+	10
28	107.1553	-6.70143	West Java	MAJALAYA2	1	-	10
29	108.3875	-6.46274	West Java	SEGERANKIDUL3	1	-	10
30	108.3881	-6.4689	West Java	033	1	-	10
31	108.3895	-6.46753	West Java	MAJALAYA1	1	-	10
32	108.4005	-6.46125	West Java	SEGERÁNKIDUL1	1	-	10
33	109.0955	1.196466	West Kalimantan	Citrus Center	1, 2, 3	-	10
34	109.1222	1.206071	West Kalimantan	BPPTEBAS	1, 2	-	10
35	109.1427	1.196811	West Kalimantan	LSUHAILI	1, 2, 3	+	10
36	109.1428	1.196774	West Kalimantan	013	1, 2	-	10

Table 1. Continued. Summary of surveillance results on the population status of *D. citri* in Indonesia, 2022–2023

Site no.	Longitude	Latitude	Province	Code	Inspection method*	ACP population**	Number of observed plants
37	109.145	1.198859	West Kalimantan	HRUSAK	1	-	10
38	109.145	1.198857	West Kalimantan	014	1	-	10
39	109.1452	1.198874	West Kalimantan	HRUSÁK2	1	-	10
40	109.1454	1.198942	West Kalimantan	HRUASAK3	1	-	10
41	109.1462	1.19746	West Kalimantan	LT2	1	-	10
42	109.1473	1.197643	West Kalimantan	POKTÁNCDAMAI1	1	-	10
43	109.1646	1.20831	West Kalimantan	TEABAS2SUNGAI2	1	-	10
44	109.17	1.223379	West Kalimantan	SEJIRAM1	1,2,3	+	10
45	109.17	1.223558	West Kalimantan	SJTELUR	1,2,3	+	10
46	109.1743	1.212236	West Kalimantan	SEJIRAM2	1,2,3	+	10
47	109.1797	1.200761	West Kalimantan	TEBASUNGAI1	1,2,3	-	10
48	109.2667	1.300354	West Kalimantan	SEMANGU1	1	-	10
49	109.2675	1.298305	West Kalimantan	SEMANGU2	1	-	10
50	109.2676	1.2982	West Kalimantan	SEMANGU2ÓK	1	-	10
51	109.2678	1.298375	West Kalimantan	SEMANGU3	1	-	10
52	109.269	1.296161	West Kalimantan	SEMANGU4	1	-	10
53	109.269	1.303105	West Kalimantan	BPPSAMBAS	1	-	10
54	109.2703	1.32466	West Kalimantan	Lahan Visit	1	-	10
55	109.288	1.365813	West Kalimantan	RA24	1	-	10
56	109.288	1.365892	West Kalimantan	RA25	1	-	10
57	109.2881	1.365996	West Kalimantan	RA26	1	-	10
58	109.2881	1.366071	West Kalimantan	RA29	1	-	10

Table 1. Continued. Summary of surveillance results on the population status of *D. citri* in Indonesia, 2022–2023

Site no.	Longitude	Latitude	Province	Code	Inspection method*	ACP population**	Number of observed plants
59	109.2881	1.366023	West Kalimantan	RA27	1	-	10
60	109.2881	1.366023	West Kalimantan	RA28	1	-	10
61	109.2881	1.3659	West Kalimantan	RA21	1	-	10
62	109.2881	1.365898	West Kalimantan	RA20	1	-	10
63	109.2881	1.365808	West Kalimantan	RA23	1	-	10
64	109.2882	1.365844	West Kalimantan	RA22	1	-	10
65	109.2882	1.366015	West Kalimantan	RA19	1	-	10
66	109.2882	1.366203	West Kalimantan	RA30	1	-	10
67	109.2882	1.366204	West Kalimantan	RA31	1	-	10
68	109.2883	1.366081	West Kalimantan	RA18	1	-	10
69	109.2883	1.366094	West Kalimantan	RA17	1	-	10
70	109.2883	1.366116	West Kalimantan	RA16	1	-	10
71	109.2884	1.366178	West Kalimantan	RA14	1	-	10
72	109.2884	1.366174	West Kalimantan	RA15	1	-	10
73	109.2884	1.366217	West Kalimantan	RA13	1	-	10
74	109.2884	1.366392	West Kalimantan	RA33	1	-	10
75	109.2884	1.366372	West Kalimantan	RA34	1	-	10
76	109.2884	1.366406	West Kalimantan	RA36	1	-	10
77	109.2884	1.366465	West Kalimantan	RA35	1	-	10
78	109.2885	1.366473	West Kalimantan	RA37	1	-	10
79	109.2885	1.365427	West Kalimantan	LAZ12	1	-	10
80	109.2885	1.366472	West Kalimantan	RA38	1	-	10

Table 1. Continued. Summary of surveillance results on the population status of *D. citri* in Indonesia, 2022–2023

Site no.	Longitude	Latitude	Province	Code	Inspection method*	ACP population**	Number of observed plants
81	109.2885	1.366517	West Kalimantan	R38	1	-	10
82	109.2885	1.366553	West Kalimantan	RA40	1	-	10
83	109.2885	1.366435	West Kalimantan	RA11	1	-	10
84	109.2886	1.366463	West Kalimantan	RA12	1	-	10
85	109.2886	1.366541	West Kalimantan	RA10	1	-	10
86	109.2886	1.365873	West Kalimantan	LAZ13	1	-	10
87	109.2886	1.366647	West Kalimantan	RA41	1	-	10
88	109.2887	1.365659	West Kalimantan	LAZ11	1	-	10
89	109.2887	1.365724	West Kalimantan	LAZ10	1	-	10
90	109.2887	1.366743	West Kalimantan	RA42	1	-	10
91	109.2887	1.365838	West Kalimantan	LAZ6	1	-	10
92	109.2888	1.36587	West Kalimantan	LAZ5	1	-	10
93	109.2888	1.365752	West Kalimantan	LAZ9	1	-	10
94	109.2888	1.366648	West Kalimantan	RA9	1	-	10
95	109.2888	1.365751	West Kalimantan	LAZ8	1	-	10
96	109.2888	1.36668	West Kalimantan	RA8	1	-	10
97	109.2888	1.3659	West Kalimantan	LAZ4	1	-	10
98	109.2888	1.366872	West Kalimantan	RA43	1	-	10
99	109.2888	1.366747	West Kalimantan	RA7	1	-	10
100	109.2888	1.366783	West Kalimantan	RA6	1	-	10
101	109.2888	1.365806	West Kalimantan	LAZ7	1	-	10
102	109.2888	1.366814	West Kalimantan	RA5	1	-	10

Table 1. Continued. Summary of surveillance results on the population status of *D. citri* in Indonesia, 2022–2023

Site no.	Longitude	Latitude	Province	Code	Inspection method*	ACP population**	Number of observed plants
103	109.2889	1.36681	West Kalimantan	RA4	1	-	10
104	109.2889	1.366793	West Kalimantan	RA3	1	-	10
105	109.2889	1.366248	West Kalimantan	LAZ14	1	-	10
106	109.2889	1.366836	West Kalimantan	RA1	1	-	10
107	109.2889	1.366822	West Kalimantan	RA2	1	-	10
108	109.2889	1.365936	West Kalimantan	LAZ3	1	-	10
109	109.289	1.366315	West Kalimantan	LAZ15	1	-	10
110	109.289	1.36604	West Kalimantan	LAZ2	1	-	10
111	109.289	1.366873	West Kalimantan	RABU2	1	-	10
112	109.2891	1.366359	West Kalimantan	LAZ16	1	-	10
113	109.2892	1.366663	West Kalimantan	LAJUZLI	1	-	10
114	109.2894	1.366475	West Kalimantan	LAZ1	1	-	10
115	109.932	-7.71223	Central Java	T07 (Purworejo)	1	-	10
116	110.0172	-7.81677	Central Java	BGLN1	1,2	-	10
117	110.2028	-7.60755	Central Java	ST01	1,2	-	10
118	110.2028	-7.6077	Central Java	T01	1,2	-	10
119	110.203	-7.60762	Central Java	T02	1,2	-	10
120	110.2031	-7.60769	Central Java	ST02	1	-	10
121	110.2031	-7.60779	Central Java	T03	1	-	10
122	110.2031	-7.60805	Central Java	ST03	1	-	10
123	110.2032	-7.60808	Central Java	T04	1	-	10
124	110.2032	-7.60825	Central Java	T05	1	-	10

Table 1. Continued. Summary of surveillance results on the population status of *D. citri* in Indonesia, 2022–2023

Site no.	Longitude	Latitude	Province	Code	Inspection method*	ACP population**	Number of observed plants
125	110.2036	-7.60858	Central Java	ST04	1,2,3	-	10
126	110.2043	-7.60866	Central Java	ST05	1,2,3	-	10
127	110.2084	-7.61013	Central Java	T06	1	-	10
128	110.3632	-7.6674	Central Java	0071	1	-	10
129	110.3632	-7.6674	Central Java	0061	1	-	10
130	110.3811	-7.76931	Yogyakarta	KFP	1	-	5
131	110.3812	-7.76945	Yogyakarta	0041	1	-	5
132	110.3826	-7.76364	Yogyakarta	0081	1	-	5
133	110.3826	-7.76365	Yogyakarta	LARÁSATI	1	-	5
134	110.3826	-7.76364	Yogyakarta	009	1	-	5
135	110.385	-7.76438	Yogyakarta	KLE1	1	-	5
136	110.3853	-7.75865	Yogyakarta	PPKN	1	-	5
137	110.3862	-7.73119	Yogyakarta	NGA4	1	+	5
138	110.3863	-7.73101	Yogyakarta	NGAN5	1	+	5
139	110.3909	-7.71607	Yogyakarta	NGAN12	1	+	5
140	110.3953	-7.70241	Yogyakarta	NAN7	1	+	5
141	110.4003	-7.71996	Yogyakarta	NGA3	1	+	5
142	110.4006	-7.7181	Yogyakarta	NGAN2	1	+	5
143	110.4016	-7.7189	Yogyakarta	NGA1	1	+	5
144	110.4017	-7.71904	Yogyakarta	NGA56	1	-	5
145	110.4147	-7.70387	Yogyakarta	NGAN8	1	-	5
146	110.4147	-7.70384	Yogyakarta	NGA9	1	-	5
147	110.4657	-7.79735	Yogyakarta	PIÁT6	1	+	5
148	110.4659	-7.79645	Yogyakarta	PIÁT2	1	+	5
149	110.4659	-7.79652	Yogyakarta	PIÁT1	1	+	5
150	110.4659	-7.79636	Yogyakarta	PÁIT3	1	+	5
151	110.4659	-7.79612	Yogyakarta	PIÁT4	1	+	5
152	110.4659	-7.79601	Yogyakarta	PIÁT5	1	+	5
153	110.5414	-7.55815	Central Java	0031	1	-	5
154	110.7661	-7.74861	Central Java	WERN	1	-	5
155	110.821	-7.75699	Central Java	WRN2	1	-	5
156	110.8528	-7.77288	Central Java	WRN3	1	-	5
157	110.8529	-7.77294	Central Java	SDH1	1	+	5
158	111.0638	-7.82329	Central Java	JTSN	1	-	5
159	111.129	-7.66801	Central Java	0121	1	-	5
160	111.4872	-7.85677	East Java	PÓ	1	+	5
161	111.4968	-7.85683	East Java	0131	1	-	5
162	111.4972	-7.86475	East Java	PONIMFÁ	1	+	5
163	111.499	-7.86314	East Java	PO1	1	+	5
164	112.5548	-7.93164	East Java	MLGDDC	1,2	-	10

Table 1. Continued. Summary of surveillance results on the population status of *D. citri* in Indonesia, 2022–2023

Site no.	Longitude	Latitude	Province	Code	Inspection method*	ACP population**	Number of observed plants
165	112.5549	-7.93202	East Java	MLG01 a	1	-	10
166	112.555	-7.93203	East Java	MLG01 b	1	-	10
167	112.5555	-7.92957	East Java	MLG03	1	-	10
168	112.5559	-7.9294	East Java	MLG02 a	1	-	10
169	112.5561	-7.92959	East Java	MLG02 b	1	-	10
170	112.5752	-7.92439	East Java	MLG04	1	-	10
171	113.4043	-8.22517	East Java	JBR07	1	-	10
172	113.4055	-8.24982	East Java	JBR06 sukoreno	1	-	10
173	113.4258	-8.18703	East Java	JBR05 img167	1	-	10
174	113.4265	-8.17739	East Java	JBR04 pref	1	-	10
175	113.4301	-8.16992	East Java	JBR1	1	-	10
176	113.4314	-8.17052	East Java	JBR2wahid	1	-	10
177	113.4323	-8.17879	East Java	JBR03	1	-	10
178	113.4652	-8.2043	East Java	JERUK TANGUL	1,2	-	10
179	113.4736	-8.2049	East Java	TANNGGUL	1	-	10
180	113.4748	-8.20448	East Java	JJ	1	-	10
181	113.4873	-8.19887	East Java	JERUK JEMBER2	1	-	10
182	114.2573	-8.52362	East Java	003	1	-	10
183	114.2574	-8.52363	East Java	004	1	-	10
184	114.2574	-8.52363	East Java	005	1	-	10
185	114.2614	-8.51949	East Java	002	1	-	10
186	114.2702	-8.53713	East Java	Tegaldlimo 1	1,2	+	10
187	114.2706	-8.53538	East Java	Tegaldlimo 2	1	-	10
188	114.2804	-8.50974	East Java	001	1	-	10
189	115.2693	-8.27917	Bali	041	1	-	10
190	115.2694	-8.27915	Bali	040	1	-	10
191	115.2715	-8.2805	Bali	039	1	-	10
192	115.2716	-8.27244	Bali	043	1	-	10
193	115.2717	-8.28038	Bali	037	1	-	10
194	115.2717	-8.28039	Bali	038	1	-	10
195	115.2717	-8.28039	Bali	036	1	-	10
196	115.2718	-8.28036	Bali	034	1	-	10
197	115.2718	-8.28036	Bali	035	1	-	10
198	115.2721	-8.27196	Bali	042	1	-	10
199	115.2867	-8.30985	Bali	BC02-lemon	1	-	10
200	115.2871	-8.30986	Bali	BC1-tanah	1	-	10
201	115.2888	-8.29481	Bali	GCP balai	1	-	10
202	115.29	-8.30644	Bali	BC3	1	-	10
203	115.29	-8.30641	Bali	BC4	1	-	10

Table 1. Continued. Summary of surveillance results on the population status of *D. citri* in Indonesia, 2022–2023

Site no.	Longitude	Latitude	Province	Code	Inspection method*	ACP population**	Number of observed plants
204	115.2902	-8.30641	Bali	BC5	1	-	10
205	115.2914	-8.30382	Bali	BC6	1	-	10
206	115.3345	-8.30933	Bali	SK1	1	-	10

*Methods: 1= Direct manual inspection; 2= Yellow sticky trap (YST); 3= Cylinder yellow trap. ** ACP population means: - = No ACP population; + = Low ACP population; +++= High ACP population.

ACP Population Status and Environmental Factors. Survey sites confirming the presence or absence of ACP populations provide valuable insights for future monitoring and management efforts. The spatial distribution of ACP populations detected using the different monitoring methods is illustrated in Figure 5. The 35 confirmed sites were primarily located on Java Island, with 19 sites distributed across East Java, Central Java, West Java, and Yogyakarta. In Sumatra, 12 confirmed sites were located around Bengkulu and Curup, while in Kalimantan, four sites were clustered in Sambas, West Kalimantan.

The distribution of ACP populations is strongly influenced by environmental conditions. Long-term patterns of temperature and precipitation over the past 20 years (Figure 6) may help explain the observed distribution of ACP populations in Indonesia. During the survey period, June to September—corresponding to the dry season—was characterized by relatively low rainfall. In contrast, rainfall increased from October through early May, corresponding to the rainy season. Notably, during 2022–2023, the wet season was longer than the dry season, with rainfall intensities ranging from 210.12% in October to 296.43% in December, which may have influenced ACP population dynamics.

ACP was detected in Indonesia, with confirmed occurrences on at least three major islands: Java, Sumatra, and Kalimantan. Our survey confirms the presence of Asian citrus psyllid (ACP) populations in citrus orchards located in key citrus-producing regions of East Java, Central Java, West Java, Bengkulu, and West Kalimantan provinces. A total of 35 sites were confirmed to harbor ACP populations across different citrus plantations (Figure 3). These 35 ACP population hotspots provide new and additional information beyond previously published records (CABI & EPPO, 2006; Subandiyah et al., 2000). Overall, ACP was detected in only 5.8% of surveyed locations, with most citrus orchards exhibiting low or very low ACP population levels. High ACP populations were limited to lowland areas of Bengkulu Province. The detection of ACP populations indicates a potential risk for the dissemination of Huanglongbing (HLB) disease in affected areas (Hosseinzadeh & Heck, 2023; Souza et al., 2024), suggesting that these sites may currently be affected by, or may become vulnerable to, HLB in the future.

The distribution and abundance of ACP populations are strongly influenced by local climatic conditions. Indonesia, a tropical country spanning both the Northern and Southern Hemispheres (Figures 4 and 5), exhibits unique climatic characteristics. Average temperatures in equatorial regions range from 20.1 ºC to 28.6 ºC (Figure 6), in contrast to subtropical regions that experience winters with markedly lower temperatures. In subtropical areas, ACP populations typically peak during spring and summer and decline to very low levels in winter (Tsai et al., 2002). In Indonesia, the dry season generally extends from early April to late September, whereas the rainy season occurs from late September to March. Citrus and other Rutaceae species initiate shoot flushing toward the end of the rainy season, creating favorable conditions for ACP growth and development. Climate data over the past 20 years indicate that the dry season in Indonesia typically begins in May–June and peaks between July and September (Figure 4). The onset of the dry season provides optimal conditions for ACP reproduction due to the availability of new shoots and favorable environmental conditions. However, favorable conditions do not necessarily result in high observable ACP populations, particularly in areas with intensive pesticide use (Pelz-Stelinski et al., 2017). Similarly, ACP populations in subtropical regions remain very low during winter because of low temperatures and limited availability of new citrus shoots (Hall et al., 2010; Rodríguez-Aguilar et al., 2023; Souza et al., 2023).

Mandarin citrus, locally known as Siamese orange, accounts for approximately 80% of citrus production in Indonesia, with the remainder consisting of various other citrus types. In this survey, except for

Table 2. Number of *Diaphorina citri* counted by direct manual inspection (DMI) at 206 locations

Site no.	Longitude	Latitude	Province	Code	Number ACP per single tree
1	102.251	-3.78786	Bengkulu	BENTENG	0
2	102.31	-3.86601	Bengkulu	KAMPBÁPTÍS	0
3	102.319	-3.90587	Bengkulu	BO4	≥30
4	102.319	-3.90584	Bengkulu	LPKASLAMÆ	0
5	102.32	-3.90575	Bengkulu	BO5RUSAK	≤30
6	102.322	-3.90406	Bengkulu	BO1	≥30
7	102.322	-3.90427	Bengkulu	BO2	≥30
8	102.322	-3.90421	Bengkulu	BO3	≥30
9	102.325	-3.90401	Bengkulu	OSS	0
10	102.326	-3.90171	Bengkulu	DJEMADIPUSAT	0
11	102.326	-3.90234	Bengkulu	DJEMADI2-++	≤30
12	102.331	-3.90649	Bengkulu	DJEMÁDI3++	≤30
13	102.345	-3.73498	Bengkulu	11	0
14	102.345	-3.73498	Bengkulu	JOHÁN	0
15	102.472	-3.36177	Bengkulu	HÁBIBÆDAUD2	0
16	102.475	-3.36136	Bengkulu	HÁBIBÆDAUD	≤30
17	102.493	-3.37732	Bengkulu	NORMAN	≤30
18	102.493	-3.37707	Bengkulu	NOR1	≤30
19	102.496	-3.37905	Bengkulu	DARLIS	≤30
20	102.497	-3.3791	Bengkulu	DETRO	≤30
21	102.585	-3.44998	Bengkulu	10	0
22	102.636	-3.48956	Bengkulu	DENI	0
23	102.638	-3.48829	Bengkulu	MEIDI	0
24	102.642	-3.48677	Bengkulu	MARKUS	0
25	102.647	-3.48546	Bengkulu	LBAWÁNG	0
26	102.649	-3.48518	Bengkulu	MEIDÍ2	0
27	107.154	-6.69873	West Java	MAJALAYA3	≤30
28	107.155	-6.70143	West Java	MAJALAYA2	0
29	108.388	-6.46274	West Java	SEGERANKIDUL3	0
30	108.388	-6.4689	West Java	33	0
31	108.39	-6.46753	West Java	MAJALAYA1	0
32	108.401	-6.46125	West Java	SEGERÁNKIDUL1	0
33	109.096	1.196466	West Kalimantan	Citrus Center	0
34	109.122	1.206071	West Kalimantan	BPPTEBAS	0
35	109.143	1.196811	West Kalimantan	LSUHAILI	≤30
36	109.143	1.196774	West Kalimantan	13	0
37	109.145	1.198859	West Kalimantan	HRUSAK	0
38	109.145	1.198857	West Kalimantan	14	0
39	109.145	1.198874	West Kalimantan	HRUSÁK2	0
40	109.145	1.198942	West Kalimantan	HRUASAK3	0
41	109.146	1.19746	West Kalimantan	LT2	0

Table 2. Continued. Number of *Diaphorina citri* counted by direct manual inspection (DMI) at 206 locations

Site no.	Longitude	Latitude	Province	Code	Number ACP per single tree
42	109.147	1.197643	West Kalimantan	POKTÁNCDAMAI1	0
43	109.165	1.20831	West Kalimantan	TEABAS2SUNGAI2	0
44	109.17	1.223379	West Kalimantan	SEJIRAM1	≤30
45	109.17	1.223558	West Kalimantan	SJTELUR	≤30
46	109.174	1.212236	West Kalimantan	SEJIRAM2	≤30
47	109.18	1.200761	West Kalimantan	TEBASUNGAI1	0
48	109.267	1.300354	West Kalimantan	SEMANGU1	0
49	109.268	1.298305	West Kalimantan	SEMANGU2	0
50	109.268	1.2982	West Kalimantan	SEMANGU2ÓK	0
51	109.268	1.298375	West Kalimantan	SEMANGU3	0
52	109.269	1.296161	West Kalimantan	SEMANGU4	0
53	109.269	1.303105	West Kalimantan	BPPSAMBAS	0
54	109.27	1.32466	West Kalimantan	Lahan Visit	0
55	109.288	1.365813	West Kalimantan	RA24	0
56	109.288	1.365892	West Kalimantan	RA25	0
57	109.288	1.365996	West Kalimantan	RA26	0
58	109.288	1.366071	West Kalimantan	RA29	0
59	109.288	1.366023	West Kalimantan	RA27	0
60	109.288	1.366023	West Kalimantan	RA28	0
61	109.288	1.3659	West Kalimantan	RA21	0
62	109.288	1.365898	West Kalimantan	RA20	0
63	109.288	1.365808	West Kalimantan	RA23	0
64	109.288	1.365844	West Kalimantan	RA22	0
65	109.288	1.366015	West Kalimantan	RA19	0
66	109.288	1.366203	West Kalimantan	RA30	0
67	109.288	1.366204	West Kalimantan	RA31	0
68	109.288	1.366081	West Kalimantan	RA18	0
69	109.288	1.366094	West Kalimantan	RA17	0
70	109.288	1.366116	West Kalimantan	RA16	0
71	109.288	1.366178	West Kalimantan	RA14	0
72	109.288	1.366174	West Kalimantan	RA15	0
73	109.288	1.366217	West Kalimantan	RA13	0
74	109.288	1.366392	West Kalimantan	RA33	0
75	109.288	1.366372	West Kalimantan	RA34	0
76	109.288	1.366406	West Kalimantan	RA36	0
77	109.288	1.366465	West Kalimantan	RA35	0
78	109.289	1.366473	West Kalimantan	RA37	0
79	109.289	1.365427	West Kalimantan	LAZ12	0
80	109.289	1.366472	West Kalimantan	RA38	0
81	109.289	1.366517	West Kalimantan	R38	0
82	109.289	1.366553	West Kalimantan	RA40	0

Table 2. Continued. Number of *Diaphorina citri* counted by direct manual inspection (DMI) at 206 locations

Site no.	Longitude	Latitude	Province	Code	Number ACP per single tree
83	109.289	1.366435	West Kalimantan	RA11	0
84	109.289	1.366463	West Kalimantan	RA12	0
85	109.289	1.366541	West Kalimantan	RA10	0
86	109.289	1.365873	West Kalimantan	LAZ13	0
87	109.289	1.366647	West Kalimantan	RA41	0
88	109.289	1.365659	West Kalimantan	LAZ11	0
89	109.289	1.365724	West Kalimantan	LAZ10	0
90	109.289	1.366743	West Kalimantan	RA42	0
91	109.289	1.365838	West Kalimantan	LAZ6	0
92	109.289	1.36587	West Kalimantan	LAZ5	0
93	109.289	1.365752	West Kalimantan	LAZ9	0
94	109.289	1.366648	West Kalimantan	RA9	0
95	109.289	1.365751	West Kalimantan	LAZ8	0
96	109.289	1.36668	West Kalimantan	RA8	0
97	109.289	1.3659	West Kalimantan	LAZ4	0
98	109.289	1.366872	West Kalimantan	RA43	0
99	109.289	1.366747	West Kalimantan	RA7	0
100	109.289	1.366783	West Kalimantan	RA6	0
101	109.289	1.365806	West Kalimantan	LAZ7	0
102	109.289	1.366814	West Kalimantan	RA5	0
103	109.289	1.36681	West Kalimantan	RA4	0
104	109.289	1.366793	West Kalimantan	RA3	0
105	109.289	1.366248	West Kalimantan	LAZ14	0
106	109.289	1.366836	West Kalimantan	RA1	0
107	109.289	1.366822	West Kalimantan	RA2	0
108	109.289	1.365936	West Kalimantan	LAZ3	0
109	109.289	1.366315	West Kalimantan	LAZ15	0
110	109.289	1.36604	West Kalimantan	LAZ2	0
111	109.289	1.366873	West Kalimantan	RABU2	0
112	109.289	1.366359	West Kalimantan	LAZ16	0
113	109.289	1.366663	West Kalimantan	LAJUZLI	0
114	109.289	1.366475	West Kalimantan	LAZ1	0
115	109.932	-7.71223	Central Java	T07 (Purworejo)	0
116	110.017	-7.81677	Central Java	BGLN1	0
117	110.203	-7.60755	Central Java	ST01	0
118	110.203	-7.6077	Central Java	T01	0
119	110.203	-7.60762	Central Java	T02	0
120	110.203	-7.60769	Central Java	ST02	0
121	110.203	-7.60779	Central Java	T03	0
122	110.203	-7.60805	Central Java	ST03	0
123	110.203	-7.60808	Central Java	T04	0

Table 2. Continued. Number of *Diaphorina citri* counted by direct manual inspection (DMI) at 206 locations

Site no.	Longitude	Latitude	Province	Code	Number ACP per single tree
124	110.203	-7.60825	Central Java	T05	0
125	110.204	-7.60858	Central Java	ST04	0
126	110.204	-7.60866	Central Java	ST05	0
127	110.208	-7.61013	Central Java	T06	0
128	110.363	-7.6674	Central Java	71	0
129	110.363	-7.6674	Central Java	61	0
130	110.381	-7.76931	Yogyakarta	KFP	0
131	110.381	-7.76945	Yogyakarta	41	0
132	110.383	-7.76364	Yogyakarta	81	0
133	110.383	-7.76365	Yogyakarta	LARÁSATI	0
134	110.383	-7.76364	Yogyakarta	9	0
135	110.385	-7.76438	Yogyakarta	KLE1	0
136	110.385	-7.75865	Yogyakarta	PPKN	0
137	110.386	-7.73119	Yogyakarta	NGA4	≤30
138	110.386	-7.73101	Yogyakarta	NGAN5	≤30
139	110.391	-7.71607	Yogyakarta	NGAN12	≤30
140	110.395	-7.70241	Yogyakarta	NAN7	≤30
141	110.4	-7.71996	Yogyakarta	NGA3	≤30
142	110.401	-7.7181	Yogyakarta	NGAN2	≤30
143	110.402	-7.7189	Yogyakarta	NGA1	≤30
144	110.402	-7.71904	Yogyakarta	NGA56	0
145	110.415	-7.70387	Yogyakarta	NGAN8	0
146	110.415	-7.70384	Yogyakarta	NGA9	0
147	110.466	-7.79735	Yogyakarta	PIÁT6	≤30
148	110.466	-7.79645	Yogyakarta	PIÁT2	≤30
149	110.466	-7.79652	Yogyakarta	PIÁT1	≤30
150	110.466	-7.79636	Yogyakarta	PÁIT3	≤30
151	110.466	-7.79612	Yogyakarta	PIÁT4	≤30
152	110.466	-7.79601	Yogyakarta	PIÁT5	≤30
153	110.541	-7.55815	Central Java	31	0
154	110.766	-7.74861	Central Java	WERN	0
155	110.821	-7.75699	Central Java	WRN2	0
156	110.853	-7.77288	Central Java	WRN3	0
157	110.853	-7.77294	Central Java	SDH1++	≤30
158	111.064	-7.82329	Central Java	JTSN	0
159	111.129	-7.66801	Central Java	121	0
160	111.487	-7.85677	East Java	PÓ++	≤30
161	111.497	-7.85683	East Java	131	0
162	111.497	-7.86475	East Java	PONIMFÁ	≤30
163	111.499	-7.86314	East Java	PO1	≤30
164	112.555	-7.93164	East Java	MLGDDC	0

Table 2. Continued. Number of *Diaphorina citri* counted by direct manual inspection (DMI) at 206 locations

Site no.	Longitude	Latitude	Province	Code	Number ACP per single tree
165	112.555	-7.93202	East Java	MLG01 a	0
166	112.555	-7.93203	East Java	MLG01 b	0
167	112.556	-7.92957	East Java	MLG03	0
168	112.556	-7.9294	East Java	MLG02 a	0
169	112.556	-7.92959	East Java	MLG02 b	0
170	112.575	-7.92439	East Java	MLG04	0
171	113.404	-8.22517	East Java	JBR07	0
172	113.406	-8.24982	East Java	JBR06 sukoreno	0
173	113.426	-8.18703	East Java	JBR05 img167	0
174	113.427	-8.17739	East Java	JBR04 pref	0
175	113.43	-8.16992	East Java	JBR1	0
176	113.431	-8.17052	East Java	JBR2wahid	0
177	113.432	-8.17879	East Java	JBR03	0
178	113.465	-8.2043	East Java	JERUK TANGUL	0
179	113.474	-8.2049	East Java	TANNGGUL	0
180	113.475	-8.20448	East Java	JJ	0
181	113.487	-8.19887	East Java	JERUK JEMBER2	0
182	114.257	-8.52362	East Java	3	0
183	114.257	-8.52363	East Java	4	0
184	114.257	-8.52363	East Java	5	0
185	114.261	-8.51949	East Java	2	0
186	114.27	-8.53713	East Java	Tegaldlimo 1	≤30
187	114.271	-8.53538	East Java	Tegaldlimo 2	0
188	114.28	-8.50974	East Java	1	0
189	115.269	-8.27917	Bali	41	0
190	115.269	-8.27915	Bali	40	0
191	115.272	-8.2805	Bali	39	0
192	115.272	-8.27244	Bali	43	0
193	115.272	-8.28038	Bali	37	0
194	115.272	-8.28039	Bali	38	0
195	115.272	-8.28039	Bali	36	0
196	115.272	-8.28036	Bali	34	0
197	115.272	-8.28036	Bali	35	0
198	115.272	-8.27196	Bali	42	0
199	115.287	-8.30985	Bali	BC02-lemon	0
200	115.287	-8.30986	Bali	BC1-tanah	0
201	115.289	-8.29481	Bali	GCP balai	0
202	115.29	-8.30644	Bali	BC3	0
203	115.29	-8.30641	Bali	BC4	0
204	115.29	-8.30641	Bali	BC5	0

Table 2. Continued. Number of *Diaphorina citri* counted by direct manual inspection (DMI) at 206 locations

Site no.	Longitude	Latitude	Province	Code	Number ACP per single tree
205	115.291	-8.30382	Bali	BC6	0
206	115.335	-8.30933	Bali	SK1	0

Table 3. Number of *Diaphorina citri* counted using yellows sticky trap (YST) at 24 locations

Sites no.	Longitude	Latitude	Province	Code	Number of ACP caught per single tree
1	102.32	-3.9058	Bengkulu	BO5RUSAK	0
2	102.322	-3.9041	Bengkulu	BO1	1
3	102.322	-3.9043	Bengkulu	BO2	1
4	102.322	-3.9042	Bengkulu	BO3	1
5	102.493	-3.3773	Bengkulu	NORMAN	1
6	102.497	-3.3791	Bengkulu	DETRO	1
7	109.096	1.19647	West Kalimantan	Citrus Center	0
8	109.122	1.20607	West Kalimantan	BPPTEBAS	0
9	109.143	1.19681	West Kalimantan	LSUHAILI	0
10	109.17	1.22338	West Kalimantan	SEJIRAM1	0
11	109.17	1.22356	West Kalimantan	SJTELUR	0
12	109.174	1.21224	West Kalimantan	SEJIRAM2	1
13	109.18	1.20076	West Kalimantan	TEBASUNGAI1	0
14	109.932	-7.7122	Central Java	T07 (Purworejo)	0
15	110.017	-7.8168	Central Java	BGLN1	0
16	110.203	-7.6076	Central Java	ST01	2
17	110.203	-7.6077	Central Java	T01	0
18	110.203	-7.6076	Central Java	T02	0
19	110.204	-7.6086	Central Java	ST04	0
20	110.204	-7.6087	Central Java	ST05	0
21	112.555	-7.9316	East Java	MLGDDC	0
22	113.406	-8.2498	East Java	JBR06 sukoreno	0
23	113.465	-8.2043	East Java	JERUK TANGUL	0
24	114.27	-8.5371	East Java	Tegaldlimo 1	0

Bengkulu (Kalamansi) and Malang (sweet orange), nearly all observation sites were mandarin orchards. Siamese orange typically flowers one to three times per year (Agustí et al., 2022), a process preceded by shoot flushing and which can increase up to sixfold in the absence of a distinct dry season (Ashari et al., 2015). Other citrus varieties generally have lower flowering frequencies, with the exception of Kalamansi. ACP requires young shoots as oviposition and breeding sites. In Indonesia, shoot flushing and flowering typically begin at the onset of the rainy season, around September (Figure 6), triggered by rainfall following a period of drought stress (Budiarto et al., 2018; Rumada et al., 2021). This period also coincides with the natural emergence and reproduction of ACP. As the rainy season peaks, ACP populations tend to decline due to high humidity. The availability of young shoots is a critical factor for ACP population growth, as nymphal development and adult emergence depend on active shoot growth. During 2022–2023, the La Niña phenomenon altered seasonal patterns, resulting in wetter-than-normal dry seasons. This anomaly caused irregular citrus growth and shoot emergence, leading to more frequent flushing and flowering—up to six

Table 4. Number of *Diaphorina citri* counted using yellow cylinder trap (YCT) at 9 locations

Site no.	Longitude	Latitude	Province	Code	Number ACP caught per single tree
1	109.096	1.19647	West Kalimantan	Citrus Center	0
2	109.143	1.19681	West Kalimantan	LSUHAILI	0
3	109.17	1.22338	West Kalimantan	SEJIRAM1	0
4	109.17	1.22356	West Kalimantan	SJTELUR	0
5	109.174	1.21224	West Kalimantan	SEJIRAM2	0
6	109.18	1.20076	West Kalimantan	TEBASUNGAI1	0
7	110.204	-7.6086	Central Java	ST04	0
8	110.204	-7.6087	Central Java	ST05	2
9	114.27	-8.5371	East Java	Tegaldlimo 1	1

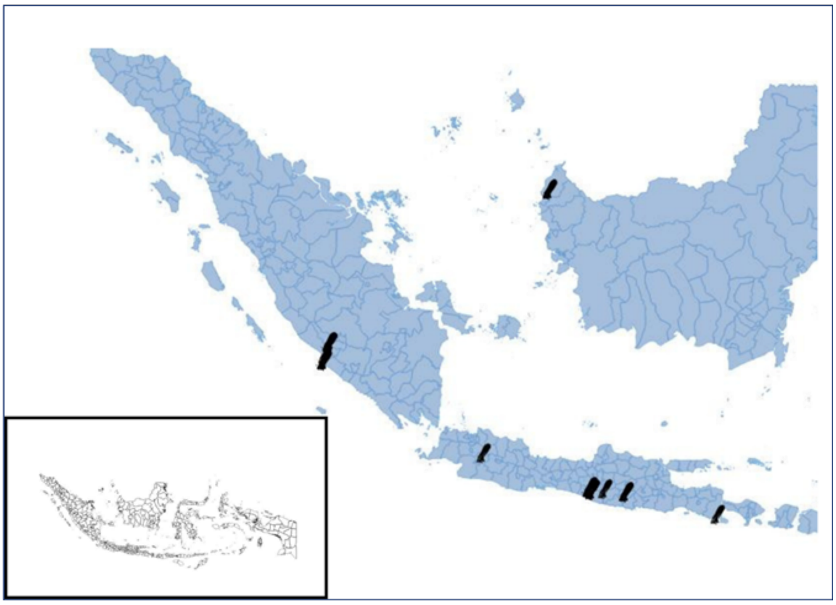

Figure. 5. Map of 35 sites confirming the distribution *Diaphorina citri* in Indonesia.

times per year (Ashari et al., 2015).

Natural enemies play a crucial role in regulating ACP populations in citrus orchards. Previous studies have documented a wide range of arthropod natural enemies of ACP, including members of the families Coccinellidae, Chrysopidae, Formicidae, Eulophidae, Syrphidae, Dolichopodidae, and Arachnida (Shrestha et al., 2021; Kondo et al., 2015). Similar natural enemy assemblages are likely present in Indonesia due to its tropical climate, which supports high biodiversity and favorable conditions for these organisms.

The mobility and flight capability of ACP facilitate its dispersal into neighboring areas with contiguous borders. The distribution of ACP in Indonesia is closely linked to that in neighboring countries, particularly those sharing land borders, such as Malaysia, Singapore, the Philippines, Timor-Leste, and Papua New Guinea (CABI & EPPO, 2006; Leong et al., 2022). The Malaysian states of Sabah and Sarawak share land borders with Kalimantan, including areas surveyed in this study, allowing relatively easy movement of ACP populations. In Papua New Guinea, ACP populations were reported between 2002 and 2004 in the Vanimo District of Sandaun Province, which borders Indonesia's Papua Province, where ACP records remain scarce (Davis et al., 2005; Davis et al., 2021; Weinert et al., 2004). This suggests that ACP populations in Papua may be older than previously documented, with the last confirmed record dating back to 1990 (CABI & EPPO, 2006), although further surveys are required to confirm this hypothesis. Similarly, ACP populations were recorded in Timor-Leste between 2000 and 2002 in several districts, including Dili, Liquica, Aileu, Ainaro,

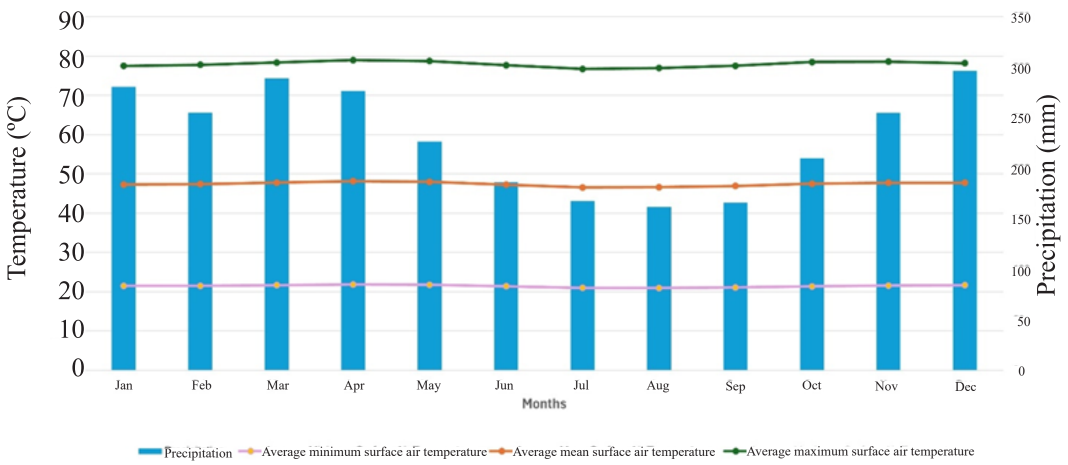

Figure 6. Monthly averages of minimum surface temperature, mean surface air temperature, maximum surface air temperature, and precipitation in Indonesia during 1991–2022.

Bobonaro, and Cova Lima (Weinert et al., 2004). Given that Timor-Leste shares a land border with Indonesia's East Nusa Tenggara Province, ACP movement into citrus plantations in this region is plausible, although no confirmed records have been reported in the past decade.

It is important to note that geographic proximity alone does not determine ACP distribution. Intensive pesticide use, particularly of compounds effective against ACP such as imidacloprid, can significantly suppress populations (Urbaneja et al., 2020). Overall, these findings indicate that ACP population dynamics in Indonesia are governed by a complex interplay of host plant availability, climatic conditions, agricultural management practices, natural enemy communities, and extreme weather events (Figure 7).

CONCLUSION

A survey conducted across Indonesia's major citrus-producing provinces, including Java, Bali, Sumatra, and Kalimantan, during the 2022–2023 period revealed that Asian citrus psyllid (ACP) populations were present at only 35 locations. ACP population levels varied considerably, with the highest densities—exceeding 30 individuals per citrus tree—observed in lowland areas of Bengkulu Province. These findings have important implications, indicating that the potential risk of Huanglongbing (HLB) disease spread may increase in regions where ACP populations are established in the future.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the Borobudur Conservation Centre Office in Magelang, Central Java, for granting permission to access plant materials within the Borobudur Temple complex. This article forms part of HS's doctoral dissertation conducted at Universitas Gadjah Mada.

FUNDING

This research was funded by the Australian Centre for International Agricultural Research (ACIAR HORT/2019/164) and the Ministry of Research and Technology, Indonesia (PDD Scheme No. 0217/E5/PG.02.00/2023 and 018/E5/PG.02.00.PL/2023).

AUTHORS' CONTRIBUTIONS

All authors contributed equally to the conception of the study, data analysis, and manuscript preparation.

COMPETING INTEREST

The authors declared that they have no competing interests.

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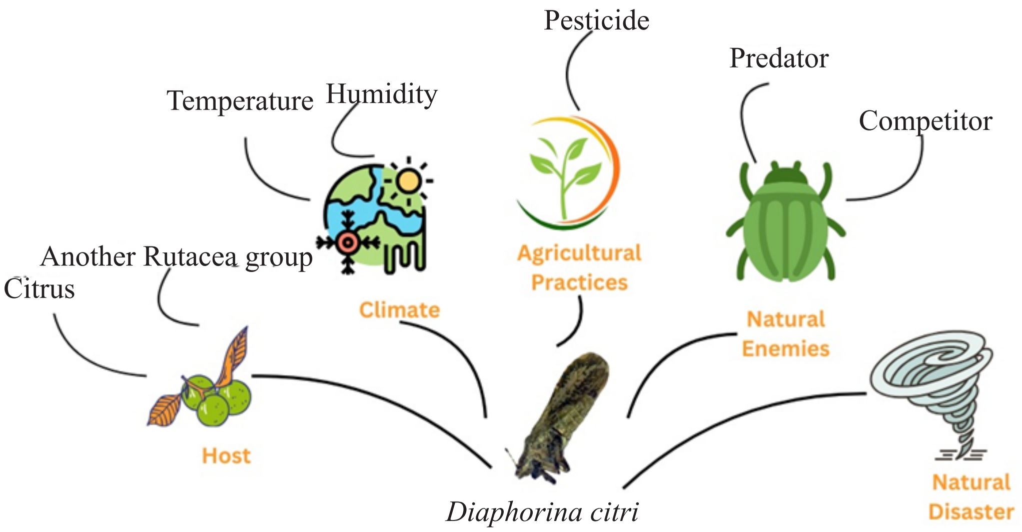

Figure 7. Analysis of factors influencing the population of *Diaphorina citri* in Indonesia during 2022–2023.

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