ABSTRACT
Alas Purwo National Park (APNP) is a conservation area with lowland forest type. The adaptation of plants conserved is strongly influenced by environmental factors and the behaviour of flowering and fruiting. The aims of this research were to find the number, species, dominance, and abundance of flowering and fruiting plants, comparison of flowering and fruting species, and environmental factors affecting the flowering and fruiting time in APNP observation tracks. This study used purposive random sampling in each observation track where flowering and fruiting plants were found. Environmental factors (temperature, humidity, light intensity, soil pH, elevation, and coordinates) in each observation track were measured. Data analysis was conducted using Microsoft Excel and PAST 4.0. statistic program. The behaviour of flowering and fruiting plants species in APNP was unique. There were 90 species of flowering and fruiting plants in APNP from 45 families. Most species often found flowering and fruiting were *Orophea enneandra*, *Polyalthia littoralis* and *Leea angulata* which were scattered in Moto Lele, Patirtan Mas, and Sadengan Savanna. Fruiting plants species were more often found than flowering ones. Temperature and light intensity became the two most affecting environmental factors on flowering and fruiting plants behaviour. The study of flowering and fruiting behaviour is very important for genetic resources conservation and conservation areas management.

Keywords: Alas Purwo National Park, behaviour, conservation, flowering, fruiting

INTRODUCTION
According to the Regulation of the Indonesian Minister of Environment and Forestry No. 46/2016 article 1 paragraph 2, a national park is a natural conservation area with an original ecosystem, managed with a zone system utilized for research, science, education, tourism, recreation and supporting cultivation. Based on this regulation, native plants of each national park area must be maintained since it is the icon of this area. The types of most national parks in eastern Java are lowland forests, including Alas Purwo National Park (APNP). Lowland rainforest becomes the dominant area of APNP with mangrove and coastal forest as additional formations on an altitude of 0-322 m asl. According to Tisnawati *et al.* (2012), more than 700 plant species were identified from 123 families within this area. Lowland rainforests were dominated by bamboo vegetation, in which the highest numbers of species were within the family of Verbenaceae and Poaceae (Hidayat, 2008). The huge number of rare plants having potential as medicine in APNP causes it to be vulnerable to exploitation (Hidayat, 2008) and the existence of native plants could be threatened.

Information concerning the adaptation of plants to their environment, especially to climate change, is available through the observation of the behaviour of flowering and fruiting since it is one of the biological activities affected by the ecological factors of a plant (Nanda *et al.*, 2017) and microclimate factors (Lestari & Sofiah, 2015). Changes in plant behaviour factors when flowering and fruiting affect the efforts for its conservation. Each plant has different flowering and fruiting behaviour (phenological characters) because it is...
influenced by genetic and environmental character (Goldsworthy & Fisher, 1992; Milla et al., 2006). Plants flowering and fruiting behaviour comprises the pattern and period of flowering and fruiting. It greatly affects the conservation efforts of these species in nature since the information of the pattern and period of flowering and fruiting leads to be understanding of plants response to their environment. In addition, it is also a very important issue in the successful management of forest genetic resources (Khanduri et al., 2013; Micheloud et al., 2018). For APNP, basic knowledge about the behaviour of the in-situ conserved flowering and fruiting plants would have a positive impact on wildlife in APNP considering the need of various wild animals in APNP is very dependent on the presence of fruits in their habitat. In return, animals in APNP also helps the natural pollination of plants conserved.

The aims of this research were to find out the number, species, dominance, and abundance of flowering and fruiting plants in each APNP observation track, to figure out the comparison of flowering and fruiting plants in APNP and environmental factors affecting the flowering and fruiting plant periods in APNP. This study was expected to be the basic for plant management in supporting in-situ conservation in APNP.

MATERIALS AND METHODS

Materials
This study was conducted in Alas Purwo National Park, Tegaldlimo, Banyuwangi, East Java Indonesia, on 15 – 27 April 2019. Observation tracks of flowering and fruiting plants behaviour were forest plantation in Rowobendo, Trianggulasi beach, Birdwatching Track (JPB), Sadengan savanna, Parang Ireng beach, Pancur beach, Istana cave, Patirtan Mas, Moto Lele, Curah Kembang and Semar Moyo (Figure 1).

Methods
The method used was purposive random sampling in each observation track. Flowering and fruiting plants in each observation track were inventoried, documented and percentage scored by Arisoesilaningisih & Soejono (2001), Hatta & Darnaedi (2005), Anderson et al. (2005) and Handayani (2016). Environmental factors such as temperature, humidity, light intensity, soil pH, elevation, and coordinates in each observation track were measured. Temperature and humidity were determined by using a thermohygrometer, light intensity by using a luxmeter, soil pH by using a pH meter, while elevation and coordinates by using a Garmin GPS. The observed parameters were the number and species of flowering and fruiting plants, the dominant number and plants in each observation track, the abundance of flowering and fruiting plants, comparison of flowering and fruiting plants, and the environmental factors affecting the flowering and fruiting behaviour. Species of flowering and fruiting plants in observation tracks were noted the number and its species. The dominant species number was counted in each observation track. The abundance of flowering and fruiting plants was counted by scoring method.

Figure 1. Research location in APNP, Banyuwangi, East Java, Indonesia (white star = observation track; ordinate: S 08°35'23.1'' E 114°20'55.9'' to S 08°43'26.1'' E 114°22'50.2'').
(Anderson et al., 2005; Handayani, 2016; Lestari, 2019). Total from each flowering plant species compared with fruiting plant species in each observation track. The effect of environmental factors on flowering and fruiting behaviour was measured by analysis of environmental factors data in each observation track using Principal Component Analysis (PCA) method.

Data were analyzed descriptively using Microsoft Excel and PAST 4.0. statistic program. PCA method was used to figure out the environmental factors affecting the plant flowering and fruiting behaviour in APNP.

RESULTS AND DISCUSSION
The behaviour of flowering and fruiting plants in each APNP observation track showed a unique characteristic. In several observation tracks, flowering and fruiting plants were dominated by one species, whereas in other tracks, those plants varied.

Number and species of flowering and fruiting plants in APNP
There were 90 flowering and fruiting plants within 45 families in APNP (Table 1). Flowering and fruiting plants varied in each observation track. Orophea enneandra, Polyalthia littoralis and Leea angulata were the most plants found flowering and fruiting in the study sites. The most flowering and fruiting plants found in the observation tracks were Euphorbiaceae.

Several plant species were found flowering and fruiting in each observation track. Flowering and fruiting plants found in more than 3 observation tracks were Chydenanthus excelsus, Corypha utan, Donax canniformis, Dyssoxylum cyrtobotryum, Ficus hispida, Ficus montana, Harrisonia perforata, Leea angulata, Leea chinensis, Memecylon floribundum, Polyalthia littoralis, Spondias pinnata, Tacca palmata, Tetracera scandens, and Uvaria grandiflora. It indicated that those plants could easily adapt to their environment and had flowering and fruiting patterns throughout the year so that they were easy to find. Plants having the same pattern including Donax canniformis (Brink & Escobin, 2003), Ficus hispida, and Ficus montana (Backer & van den Brink, 1968), Orophea enneandra (Lestari, 2019), and Tetracera scandens (van Valkenburg & Bunyapraphatsara, 2002). Some plants have an uncertain flowering season and it is mostly unaffected by climate such as Tacca palmata (Lemmens & Bunyapraphatsara, 2003). Flowering season can also be influenced by pollinators, pollination types, and predators. Because flowering and fruiting behaviour were associated with biotic and climatic factors interaction (da Maia et al., 2013; Mohandass et al., 2018). Meanwhile, there are plants flowering and fruiting once or twice a year and the time is exactly the same as this research activity. For example, Dyssoxylum cyrtobotryum in India flowers from February to April, while the fruits ripe from June to July (Kumar, 2009). As a result of climate differences in Indonesia, there may be a slight shift for fruit

| No | Species | Observation track |
|----|---------|------------------|
|    |         | RWB TRB JPB SS PIB PCB IC PM ML CK SM |
| 1  | *Aglaonema simplex* (Blume) Blume | + |
| 2  | *Aleurites moluccanus* (L.) Wild. | + |
| 3  | *Allophyllus cobbe* (L.) Raeusch. | + |
| 4  | *Alocasia gigantean* (Schott) G.Don | + |
| 5  | *Alstonia spectabilis* R.Br. | + |
| 6  | *Antidesma bunius* (L.) Spreng | + |
| 7  | *Antidesma montanum* Blume | + |
| 8  | *Archidendron bigeminum* (L.) I.C.Nielsen | + |
| 9  | *Ardisia elliptica* Thunb. | + |
| 10 | *Ardisia humilis* Vahl. | + |
| 11 | *Ardisia sp.* | + |
| 12 | *Arytera serrata* | + |
| 13 | *Bambusa blumeana* Schult.f. | + |
| 14 | *Bischofia javanica* Blume | + |
| 15 | *Calophyllum inophyllum* L. | + |
| No | Species | Observation track |
|----|---------|--------------------|
| 16 | Canarium hirsutum Willd. | + |
| 17 | Canavalia rosea (Sw.) DC. | + |
| 18 | Casearia ipecacuanha (Brot.) L. Andersson | + |
| 19 | Casearia grewifolia Vent. | + |
| 20 | Cassia fistula L. | + |
| 21 | Randia sp. | + |
| 22 | Cerbera odollam Gaertn. | + |
| 23 | Cheilocostus speciosus (J.Koenig) C.D. Specht | + |
| 24 | Chrydenanthus excelsus (Blume) Miers | + |
| 25 | Cleistanthus collinus (Roxb.) Benth. ex Hook.f. | + |
| 26 | Corypha utan Lam. | + |
| 27 | Crotalaria juncea L. | + |
| 28 | Diospyros cadiflora Blume | + |
| 29 | Diospyros martitima Blume | + |
| 30 | Diospyros vera (Lour.) A.Chev. | + |
| 31 | Donax canniformis (G.Forst.) K.Schum. | + |
| 32 | Drypetes serrata (Maycock) Krug & Urb. | + |
| 33 | Gnetum gnemon L. | + |
| 34 | Embelia ribes Burm.f. | + |
| 35 | Ficus racemosa L. | + |
| 36 | Ficus callophylla Blume (1) | + |
| 37 | Ficus callophylla Blume (2) | + |
| 38 | Ficus callosa Willd. | + |
| 39 | Ficus drupacea Thunb. | + |
| 40 | Ficus hispida L.f. | + |
| 41 | Ficus montana Burm.f. | + |
| 42 | Ficus variegata Blume | + |
| 43 | Gnetum gnemon L. | + |
| 44 | Grewia asiatica L. | + |
| 45 | Harpullia arborea (Blanco) Radlk. | + |
| 46 | Harrisonia perforata (Blanco) Merr. | + |
| 47 | Hernandia symphoefolia (J.Presl) Kubitzki | + |
| 48 | Ipomoea pes-caprae (L.) R. Br. | + |
Table 1. Contd.

| No | Species | Observation track |
|----|---------|-------------------|
| 51 | Ixora smerensis Bremek. | + |
| 52 | Ixora sp. | + |
| 53 | Knema cinerea (Poir.) Warb. | + + |
| 54 | Lantana camara L. | + + |
| 55 | Lea angulata Korth. ex Miq. | + + + + |
| 56 | Lea chinensis | + + + |
| 57 | Mallotus dispar (Blume) Mull.Arg. | + |
| 58 | Mallotus sp. | + |
| 59 | Memecylon floribundum Blume | + + + |
| 60 | Mimosa pudica L. | + |
| 61 | Musa acuminata Colla | + |
| 62 | Nauclea sp. | + |
| 63 | Nicokia sp. | + |
| 64 | Ochrosia ackeringse (Teijsm. & Binn.) Miq. | + |
| 65 | Oplismenus burmanni (Retz.) P.Beauv. | + |
| 66 | Orophea enneandra Blume | + + + + |
| 67 | Palaquium sp. | + |
| 68 | Pangium edule Reinw. | + |
| 69 | Pentia indica L. | + |
| 70 | Phaleria capitata Jack. | + + + |
| 71 | Physalis angulata L. | + |
| 72 | Piper cubeba L.f. | + |
| 73 | Piper retrofractum Vahl. | + |
| 74 | Polyalthia littoralis (Blume) Boerl. | + + + |
| 75 | Sandoricum koejla (Burm.f.) Merr. | + |
| 76 | Pseuderanthemum carruthersii (Seem.) Guillaumin | + + |
| 77 | Senna siamea (Lam.) H.S. Irwin & Barneby | + + |
| 78 | Spondias pinnata (L.f.) Kurz. | + + + |
| 79 | Sterculia foetida L. | + |
| 80 | Suregada gloveriata (Blume) Baill. | + |
| 81 | Tabernaemontana pandacaqui Lam. | + |
| 82 | Tabernaemontana sphaerocarpa Blume | + |
| 83 | Tabernaemontana sp. | + |
| 84 | Tacca leontepetaloides (L.) Kuntze | + |
| 85 | Tacca palmata Blume | + + + |
ripening i.e. in April. *Polyalthia littoralis* which is ex-situ conserved in Purwodadi Botanic Garden and resulting from plant exploration activity in APNP, have twice a year flowering pattern and once a year fruiting pattern, from January to August (Handayani, 2016; Lestari, 2019). *Uvaria grandiflora* has a fruiting period from January to May (Lestari, 2019) in Purwodadi Botanic Garden. *Spondias pinnata* in southeastern India has a fruiting period from June to November, and probably due to the different seasons, it has an earlier fruiting period in May. Some species of *Spondias* fruit in May or approaching May in the tropics (Mitchell & Daly, 2015). *Corypha utan* has flowering and fruiting period only once i.e. at the end of its life (Heyne, 1987).

The dominant plants and their number in each observation track

The observation track with the most flowering and fruiting plants was Moto Lele (20%), followed by Patirtan Mas and Sadengan savanna (12%) (Figure 2). The dominant flowering and fruiting plants in each observation track varied. The dominant flowering and fruiting plants in Rowobendo Forest Plantation were *Piper cubeba*, *Piper retrofractum* (fruiting), and *Suregada glomerulata* (flowering and fruiting). *Casearia gravifolia* was only found fruiting on the edge of Trianggulasi beach. *Orophea enneandra* was found flowering in Bird Watching Path (JPB), Istana Cave (flowering), Patirtan Mas, and Curah Kembang. Two species were found flowering in two different locations, namely *Lea angulata* in Sadengan savanna and Moto Lele, and *Polyalthia littoralis* in JPB and Moto Lele. *Ficus hispida* and *Diospyros maritima* were found fruiting along the Parang Ireng beach. On the edge of Pancur beach, many *Corypha utan* were found fruiting. Besides *Orophea enneandra*, *Tacca palmata* and *Ficus montana* were found fruiting in the Istana cave. *Bambusa blumeana* was also found blooming in Moto Lele, besides *Polyalthia littoralis* and *Lea angulata* that were fruiting (Figure 3). There was no dominant flowering and fruiting plants in Semar Moyo.

Flowering and fruiting plants in Moto Lele were more numerous than other observation tracks. It was because it had warm air temperature (32.34°C), medium level of humidity (65.2%), and light intensity (665.28 lux) to support the process of plant metabolism. Therefore, it was more optimal for flower and fruit formation than others. Sufficient light intensity affects the level of photosynthesis as the source of energy for the flowering process. Denser vegetation canopy in other observation tracks causes less light intensity hence the growth and development of fruit would not be optimized. Low light intensity is closely related to PAR (Photosynthetically Active Radiation), where the denser canopy level causes low PAR value and vice versa. Plants experience a double decline in fruit production under low light intensity, which is closely related to the distribution of carbon to the fruit and influenced by the balance between starch and sucrose (Sitompul, 2010). Moto Lele was a type of natural forest with fairly dense vegetation canopy.

### Table 1. Contd.

| No | Species | Observation track |
|----|---------|-------------------|
| 86 | *Tetracera scandens* (L.) Merr. | + | + | + | + |
| 87 | *Uvaria grandiflora* Roxb. ex Hornem | + | + | + | + |
| 88 | *Voacanga grandifolia* (Miq.) Rolfe | + |
| 89 | *Vitex pinnata* L. | + | + |
| 90 | *Vitis* sp. | + |

Note: RWB = Rowobendo Forest Plantation, TRB = Trianggulasi Beach, JPB = Birdwatching Track, SS = Sadengan Savanna, PIB = Parang Ireng Beach, PCB = Pancur Beach, IC = Istana Cave, PM = Patirtan Mas, ML = Moto Lele, CK = Curah Kembang, SM = Semar Moyo.
and still relatively native (Darmayanti et al., 2019). Thus, it became the preferred habitat for butterflies. The butterflies found in APNP were 39 species and some of them were classified as pollinators (Budiarto, 2014). Besides that, there found vulnerable bird species such as *Leptoptilos javanicus* and *Pavo muticus* in Sadengan savanna as a representation of ideal place to take a rest and to forage (Widodo, 2016). There are 13 bats species with 2 Near Threatened species playing role as zoopollinator known to be scattered in the cave area of APNP (Rianti et al., 2009). The number of zoopollinator living in forest areas certainly influences the number of pollinated plants and thus the number of fruiting plants.

**The abundance of flowering and fruiting plants**

The abundance of flowering and fruiting plants in each observation track was shown in Figure 4. Species with the greatest abundance in each observation track were *Calophyllum inophyllum* in Rowobendo Plantation Forest, *Tacca palmata* in Istana cave, and *Corypha utan* in Moto Lele.

**Comparison of flowering and fruiting plants number**

Based on Figure 5, it can be inferred that the number of fruiting plants in each observation track...
is more than flowering ones. Even in JPB, Curah Kembang, and Semar Moyo, there were no flowering plants found. Observation tracks where flowering plants were mostly found in Moto Lele, followed by Sadengan savanna and Parang Ireng beach. While fruiting plants were mostly found in Moto Lele, followed by Patirtan Mas and JPB.

The numbers of fruiting plants were more than the flowering ones. According to Anderson et al. (2005), the peak of the flowering season in tropics usually in the wet season. Meanwhile, this research was carried out during the dry season, so that the number of flowering plants was less than the fruiting ones. Flowering initiation is influenced by external factors such as environment and also stimulated by endogenous factors such as hormonal factors, flowering time initiation, and an adequate carbon or nitrogen balance (Larcher, 1995). During the dry season, immature fruits are formed immediately after the flowers bloom. Immature fruits take several months to become ripe fruits (Arisoesilaningsih et al., 2001).

**Influence of environmental factors on flowering and fruiting behaviour**

Based on Table 2, range of general environmental conditions in the observation track were 29.8-32.34° C (temperature), 65.2 – 77.88% (humidity), 21.7-73 m asl (elevation), 6-7 (soil pH), 83.2-2306.75 lux (light intensity) and the coordinates location was between S 08°35'23.1" E 114°20'55.9" to S 08°43'26.1" E 114°22'50.2". The influence of environmental factors on the number of flowering and fruiting plants was shown in Figure 6.

Temperature and light intensity were the two most influential factors of the flowering and fruiting period in APNP, especially in Rowobendo Plantation Forest, JPB, Sadengan savanna, Parang Ireng beach, Istana cave, and Moto Lele. The numbers of flowering and fruiting plants found in those observation tracks were more compared to other regions.

Environmental factors influencing the plants to flower are humidity, temperature, sunlight, rainfall, and nutrients (Sulistyawati et al., 2012). Based on Figure 6, temperature and light intensity are environmental factors affecting the behaviour of flowering and fruiting plants found in observation tracks. Microclimate is the most important factor and has a significant effect on flowering and fruiting behaviour.
Time or period is an important component in plant reproduction. Individual plants with early flowering would have a limited capacity to produce fruit (Milla et al., 2006; Khanduri, 2014). Certain plants produce fruits from flowers in a very short period, but other plants require a longer time. This behaviour is very important and useful in planning the conservation improvement programs and strategies for a plant species. The need to recognize the flowering and fruiting behaviour of a plant species and observe its phenological development is very closely related to its ecological studies (Augspurger, 1983; Abu-Asab et al., 2001). In addition, the study of flowering and fruiting plant

Table 2. Average of microclimate factors in each observation track; RWB = Forest Plantation of Rowobendo, TRB = Trianggulasi Beach, JPB = Birdwatching Track, SS = Sadengan Savanna, PIB = Parang Iręng Beach, PCB = Pancur Beach, IC = Istana Cave, PM = Patirtan Mas, ML = Moto Lele, CK = Curah Kembang, SM = Semar Moyo.

| Observation track | Temperature (°C) | Humidity (%) | Elevation (m asl) | Soil pH | Light intensity (lux) | Coordinate | Flowering | Fruiting | Total |
|-------------------|-----------------|--------------|------------------|--------|-----------------------|------------|-----------|----------|-------|
| RWB               | 30.75           | 74.4         | 29.6             | 6.67   | 937.56                | S 08°38'24,6" E 114°20'55,9" | 3         | 14       | 16     |
| TRB               | 30.7            | 75.5         | 26.13            | 6.68   | 1181.13               | S 08°38'40,8" E 114°21'23,7" | 3         | 8        | 10     |
| JPB               | 31.32           | 74.07        | 33.21            | 6.59   | 591.58                | S 08°39'11,1" E 114°21'43" | 0         | 17       | 17     |
| SS                | 30.9            | 69.88        | 27               | 6.6    | 1193.75               | S 08°39'05,7" E 114°22'00,8" | 5         | 15       | 18     |
| PIB               | 30.48           | 70.5         | 28.25            | 6.75   | 2306.75               | S 08°41'05,6" E 114°22'30,3" | 5         | 10       | 14     |
| PCB               | 31.7            | 71           | 30               | 6      | 6200                  | S 08°40'42,3" E 114°22'27,2" | 2         | 3        |        |
| IC                | 31.42           | 68.4         | 43.6             | 6.56   | 1156.15               | S 08°40'17,7" E 114°22'27,2" | 1         | 11       | 11     |
| PM                | 30.06           | 77.88        | 70.88            | 6.56   | 544.1                 | S 08°37'53,4" E 114°22'32,4" | 3         | 18       | 18     |
| ML                | 32.34           | 65.2         | 21.7             | 6.78   | 665.28                | S 08°42'29,6" E 114°22'14,3" | 10        | 26       | 31     |
| CK                | 29.8            | 76           | 62               | 7      | 83.2                  | S 08°35'23,1" E 114°22'05,0" | 0         | 12       | 12     |
| SM                | 30.1            | 69           | 73               | 7      | 624                   | S 08°36'39,1" E 114°22'19,8" | 0         | 1        | 1      |

periods compared to height and location (Panchen, 2016).
behaviour is important from the perspective of genetic resources conservation and conservation areas management (Omondi et al., 2016). Especially for in-situ conservation areas, such as APNP, where fauna becomes one of the important components in its ecosystem. Flowering plants provide many benefits, beside become food sources, they also become places to lay eggs, hiding, and inviting other fauna species in the ecosystem such as pollinators, natural enemies, as well as other ecological functions. Through flowering and fruiting plants, the ecosystem would be more stable, thus the ecosystem components balance could be maintained (Kurniawati & Martono, 2015).

CONCLUSION
There were 90 species of flowering and fruiting plants in APNP from 45 families. Most species often found flowering and fruiting were *Orophea enneandra*, *Polyalthia littoralis*, and *Leea angulata* which were scattered in Moto Lele, Patirtan Mas, and Sadengan Savanna. Fruiting plants species were more often found than flowering ones. Temperature and light intensity became the two most affecting environmental factors on flowering and fruiting plants behaviour.

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