CHAPTER 4

Results

4.1 Seed removal

Seed removal of five species was recorded every week. The generalized linear model (GLM) indicated significant effects of species and treatments on seed removal. The five species were divided to two groups: 1) low proportion of seed removal (*H. dulcis, A. kurzii*, *P. cerasoides* and *C. axillaris*) and 2) high proportion of seed removal (*H. glabra*) (Figure 4.1). For the former species, the average seed removal in the field of *P. cerasoides*, *H. dulcis*, *A. kurzii* and *C. axillaris* were 0.67 ± 0.67, 1.11 ± 0.86, 1.11 ± 0.61 and 2.44 ± 0.96 percent, respectively (Figure 4.1, C). In the GLM, differences in the proportion of seed removal among the four species were not significant. The predicted probability of seed removal of the species in the control treatment varied from 0.005 to 0.018 (Figure 4.2, Appendix C).

H. glabra was the only species with high seed removal. The average seed removal in the field was 85.78 ± 11.41 percent (Figure 4.1, A). The GLM showed that the probability of *H. glabra* seeds being removed in the control treatment was about 206 times greater than that of *P. cerasoides, H. dulcis, A. kurzii*, and *C. axillaris* (Coefficient estimate ± SE = 10.563 ± 1.785, z = 5.918, P < 0.001).

Comparisons among treatments showed that the cage treatment significantly decreased the proportion of seed removal compared with the control (Coefficient estimate ± SE = -5.583 ± 1.618, z = -3.450, P < 0.001). The insecticide plus cage treatment was marginally effective at protecting seeds from being removed. The open cage, and insecticide treatment did not prevent seed removal significantly (Figure 1).

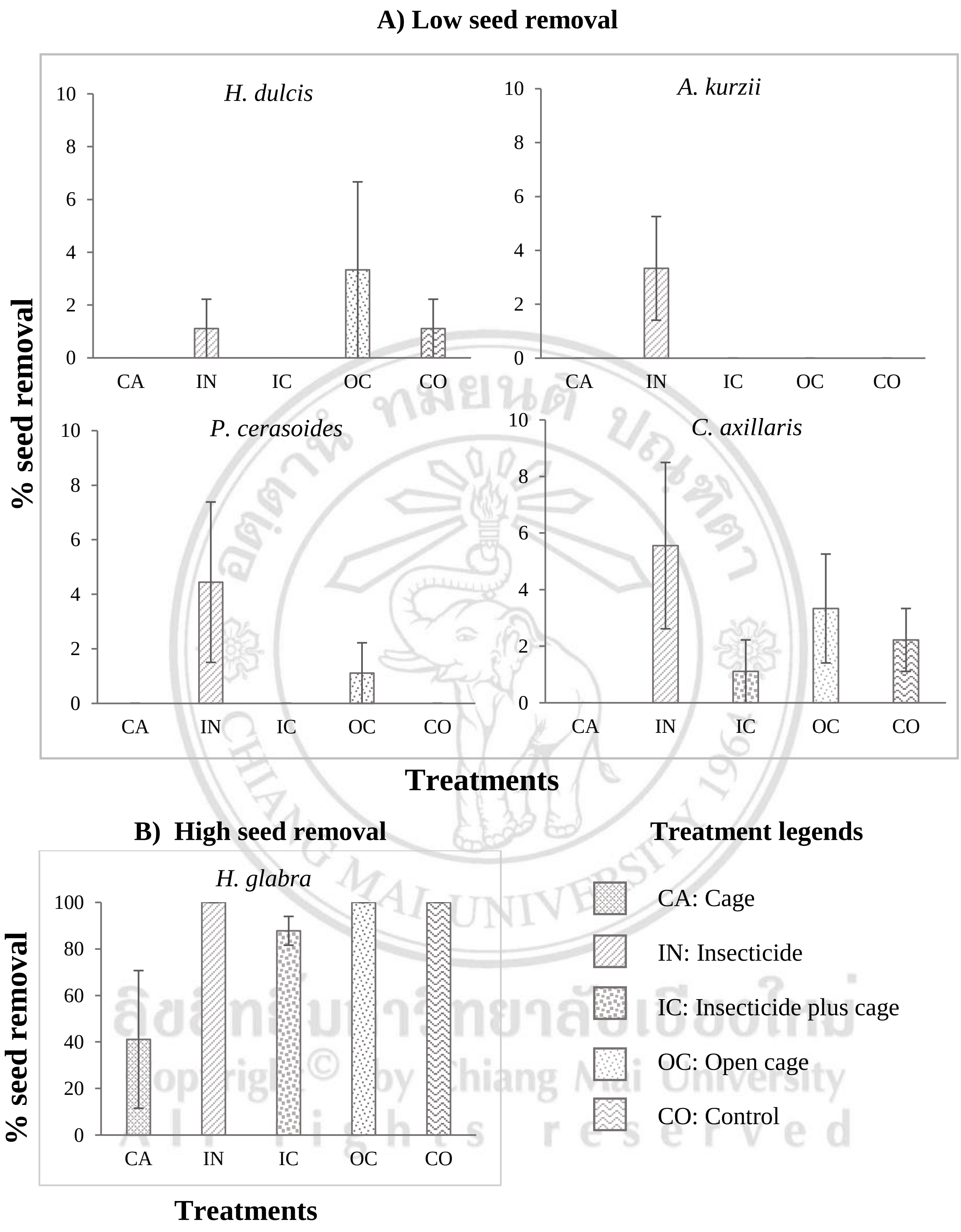

Figure 4.1 Actual percent seed removal from the field data (three replicates of 30 seeds per replicate). Tree species were categorized into two groups according to the generalized linear model (GLM). Each graph shows percent seed removal (±1SE) in five treatments; CA: cage (▩), IN: insecticide (▨), IC: insecticide plus cage (▩), OC: open cage (▩), CO: control (▩).

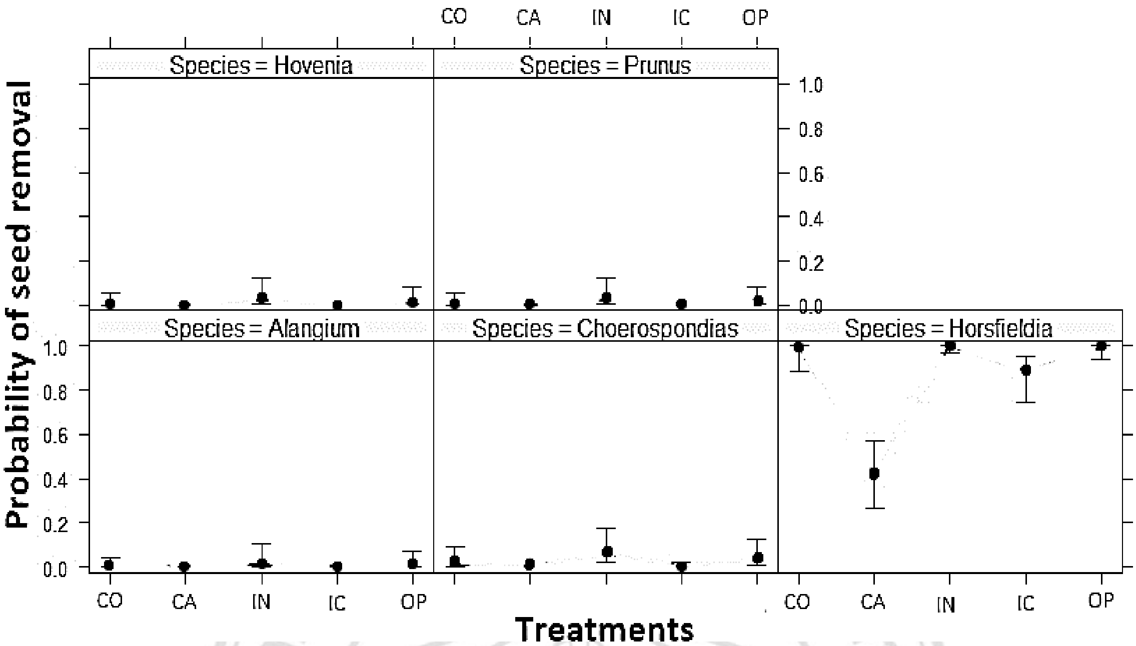

Figure 4.2 Effect plots represent the proportion of seed removal predicted from the generalized linear model (GLM). Each panel shows the prediction (±1SE) of each tree species in five treatments including CO (control), CA (cage), IN (insecticide), IC (insecticide plus cage) and OP (open cage).

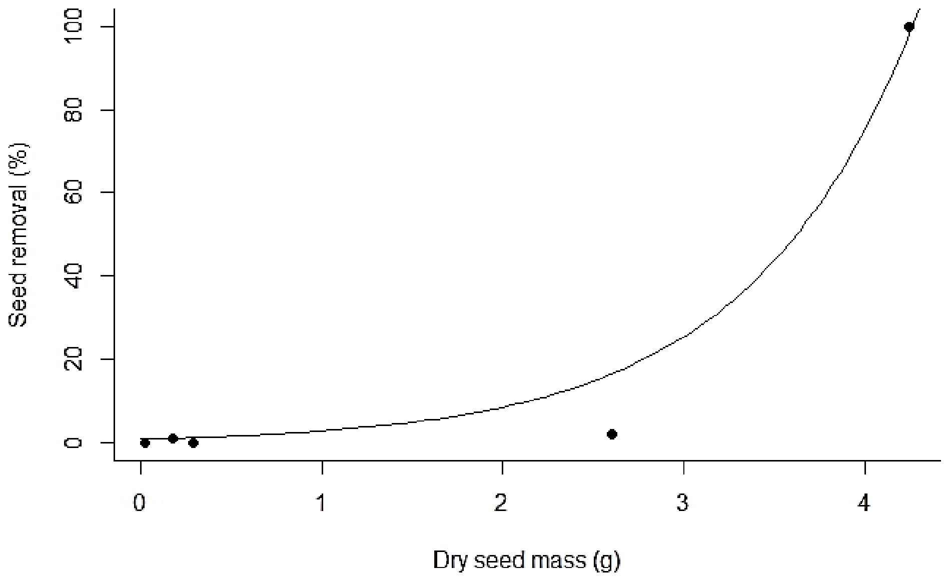

Figure 4.3 Relationship between the percent seed removal and dry seed mass (the non-linear equation: seed removal (y) = e $^{(1.081x)}$, residual standard error = 7.302 on 4 df and p-value < 0.001)

In addition, the relationship between seed mass and mean percent seed removal (control treatment) was determined by a non-linear regression through the origin. The mean percent removal was increased with increase in seed mass (coefficient estimate ± SE = 1.081 ± 0.017, t = 62.25, P = 0.0271; Figure 4.3)

4.2 Seed germination

Seed germination in the field

In the field experiment, percent seed germination was calculated as the number of germinated seeds, divided by the number of seeds that remained after seed removal. For *H. glabra* no seeds germinated in the field. Therefore, *H. glabra* was not included in the analysis of seed germination and *H. glabra* was classified into no germination group (Figure 4.4 - 4.5).

For the other four species, the GLM showed that treatments had no effect on the proportion of seeds that germinated in comparison with the controls (see in Appendix C). Averaging across species, seed germination was 44.27 ± 8.40 percent with insecticide, 45.80 ± 11.19 percent for the control, 47.62 ± 17.54 percent in open cages, 53.74 ± 14.84 percent with insecticide plus cages and 54.72 ± 19.04 percent in closed cages.

The GLM indicated germination ability differed significantly among the four tree species. *A. kurzii* (73.55 ± 5.61 percent) and *P. cerasoides* (72.54 ± 5.19 percent) germinated the most (Coefficient estimate ± SE = 1.012 ± 0.212, z = 4.762, *P*-value < 0.001). *C. axillaris* (33.36 ± 2.80 percent) germinated morderately, whilest *H. dulcis* germinated the least with 17.46 ± 2.12 percent germination (Figure 4.4). The predicted probability of seed germination of tree species in the control treatment varied from 0.17 to 0.73 (Figure 4.5, Appendix C).

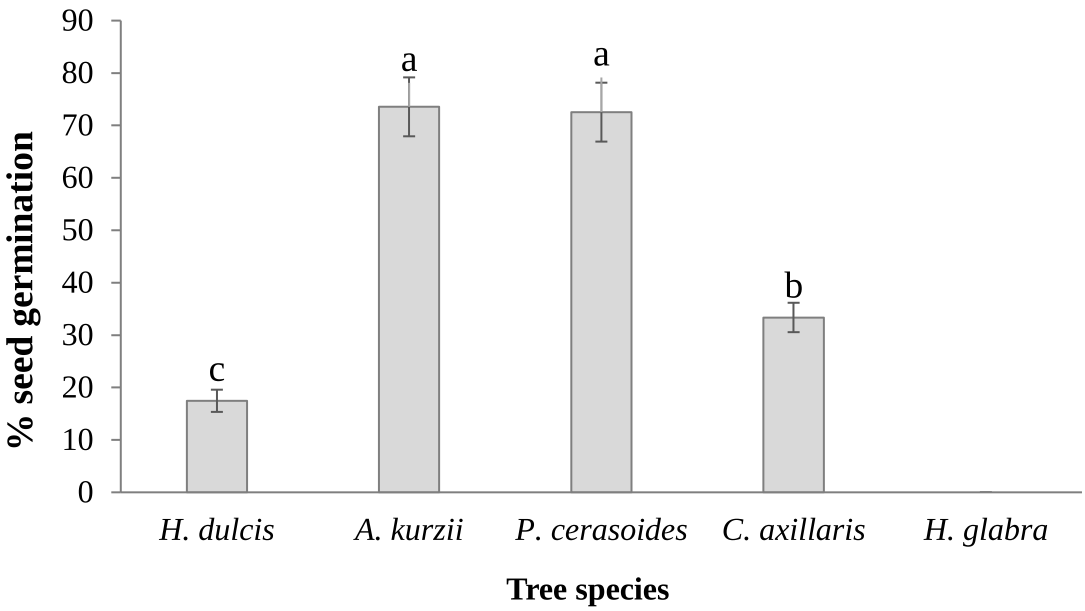

Figure 4.4 Actual percent seed germination (±1SE) from the field data (three replicates of 30 seeds per replicate) averaged across all treatments of the five studied species. The letter (a - c) represent significant differences among tree species compared with *H. dulcis* according to the generalized linear model (GLM).

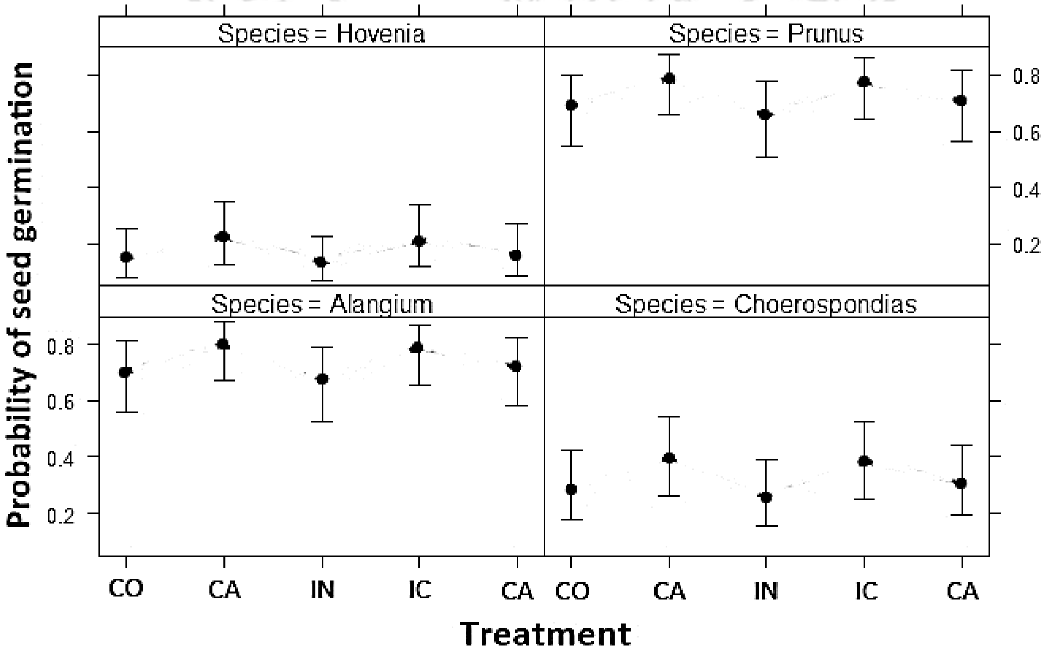

Figure 4.5 Effect plot represents the proportion of seed germination predicted from the GLM. Each panel shows the prediction (±1SE) of each tree species in five treatments, including CO (control), CA (cage), IN (insecticide), IC (insecticide plus cage) and OP (open cage).

Seed germination in the nursery

The insecticide treatment had no significant effect on seed germination. Survival analysis (N = 90 seeds per treatment) showed no significant difference between the insecticide spraying and the control treatment (Chi-square < 3.84, at significant level of 0.05) for the four species (Figure 4.6).

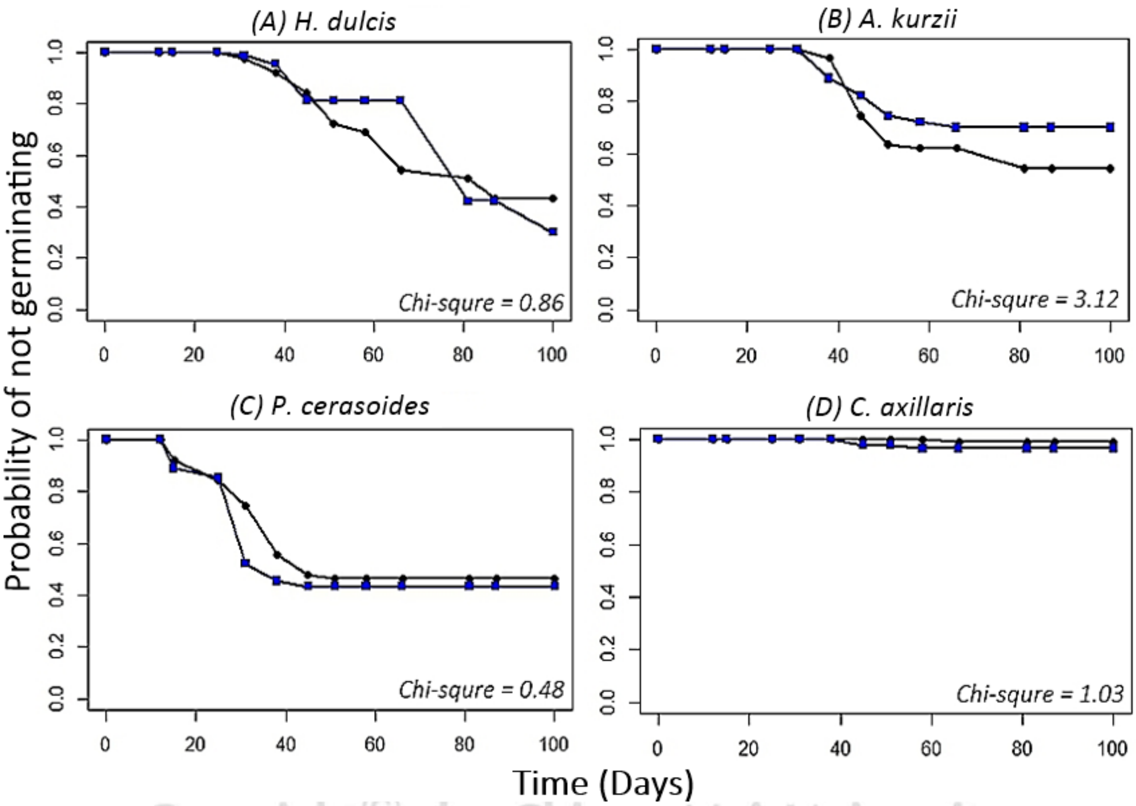

Figure 4.6 Survival plot showed probability of not germinating of seeds in two treatments: insecticide spraying (—■—) and no insecticide apply (control; —●—). Log-rank test (Chi-square test, *df* = 1, Critical value = 3.84) was used to determine the difference between treatments.

Germination between nursery and field

For each species the percent seed germination in the control treatment of the field experiment was compared to that of the nursery experiment. *H. dulcis* had significantly higher germination in the nursery (60.00 ± 4.84 percent) than in field (17.78 ± 2.22 percent). Unlike *H. dulcis,* C. *axillaris* and *A. kurzii* had higher germination in field than in the nursery experiment (Chi-square < 3.84, at significant level of 0.05). Seed germination of *P. cerasoides* was more than 70 percent in both field and nursery experiments and did not differ between the two conditions (Chi-square = 2.92 at significant level of 0.05) (Figure 4.7).

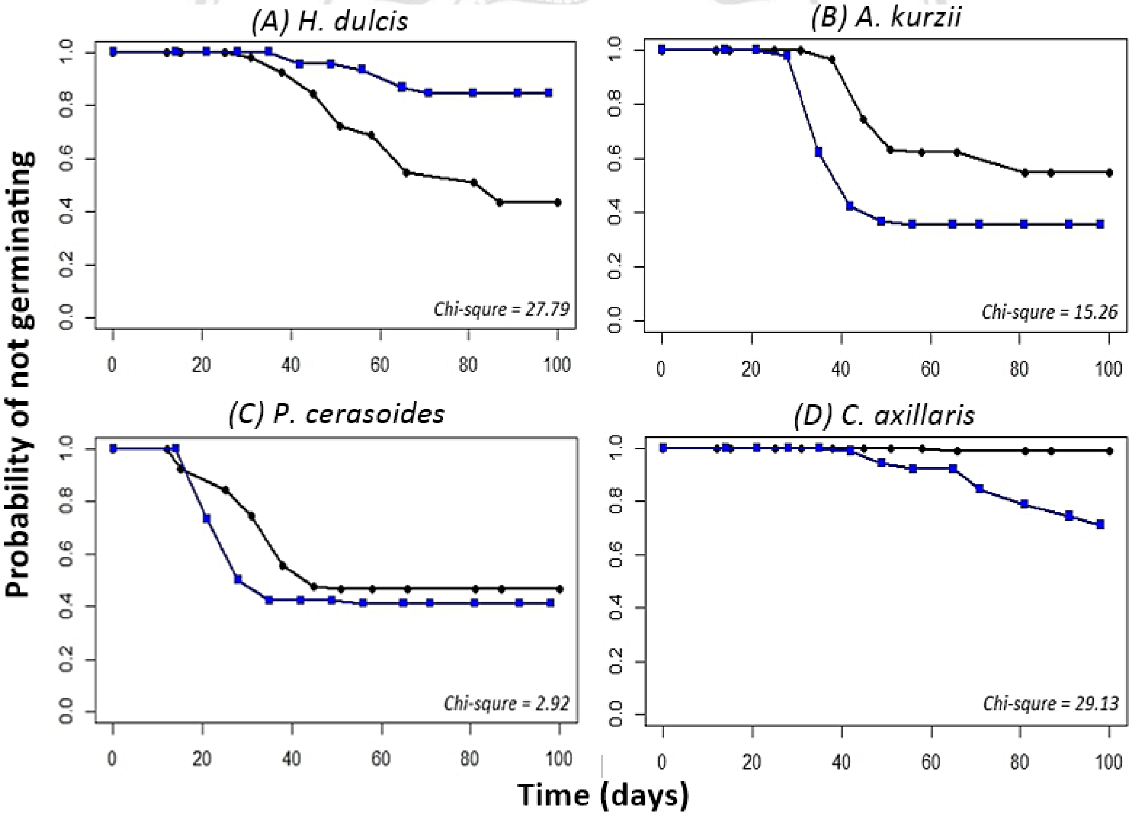

Figure 4.7 Survival plot showed probability of not germinating of seeds in two conditions: field experiment (—■—) and in tree-nursery (control; —●—). Log-rank test (Chi-square test, *df* = 1, Critical value = 3.84) was used to determine the difference between experiments.

4.3 Cotyledonous-seedling and leafy-seedling mortality

Cotyledonous-seedling mortality

The GLM indicated that the species and treatments affected seedling mortality. However, the effect of species was statistically marginal. Among species, the mean percent mortality of cotyledonous-seedlings ranged from 0.71 ± 0.71 percent (*H. dulcis*) to 7.92 ± 2.35 percent (*P. cerasoides*). The cotyledonous-seedling mortality of *C. axillaris*, and *H. dulcis* was marginally lower than that of *A. kurzii*, and *P. cerasoides* (Figure 4.8; Appendix C).

Among treatments, the GLM showed that the cage and the insecticide plus cage treatments significantly decreased mortality compared with the control (Coefficient estimate of cage treatment ± SE = -1.729 ± 0.656, z = -2.634, *P*-value = 0.008; coefficient estimate of insecticide plus cage treatment ± SE = -1.3592 ± 0.5897, z = -2.305, *P*-value = 0.02). The probability of cotyledonous-seedlings dying in the cage treatment was 0.18 times lower than that in the control with the insecticide plus cage treatment, the probability of dying was 0.26 times lower than that in the control treatment (Figure 4.9).

Leafy Seedling mortality

Leafy-seedling mortality ranged from 11.93 ± 2.53 percent for *C. axillaris* to 40.80 ± 9.80 percent for *H. dulcis* (Figure 4.10). The GLM indicated that the effect of the treatments on the leafy-seedling mortality was insinificant (Appendix C), but leafy-seedling mortality did differ among species. *H. dulcis* had the highest leafy seedlings mortality (Coefficient estimate ± SE = -2.032 ± 0.790, z = -2.572, P-value = 0.010). Prediction model from GLM showed probability of leafy seedling mortality in *H. dulcis* was 0.024 across treatments (Figure 4.11, Appendix C).

Comparison of cotyledonous-seedling and leafy-seedling mortality

Across species, the average percent mortality per day was higher in the cotyledonous-seedling stage (0.59 ± 0.21 percent per day) than the leafy-seedling stage (0.15 ± 0.05 percent per day) (Figure 4.12). For *H. dulcis* and *C. axillaris,* the seedling mortality was not significantly different between the two stages (see in Appendix C). On the other hand, *P. cerasoides* and *A. kurzii* had significantly higher percent cotyledonous-seedling mortality per day compared with the percent leafy-seedling mortality (t = 2.674, df = 5.176, p-value = 0.043 for *A. kurzii* and t = 2.978, df = 5.015, p-value = 0.031 for *P. cerasoides*) (Figure 4.12).

Cause of seedling mortality

In addition, physical appearance of dead seedlings was examined to infer causes of dead in the field. There were three categories of seedlings - 1) seedlings with only stem and leaves absent), 2) dried-out seedlings, and 3) disappeared seedlings (no remaining stem in the bamboo tube) (Figure 4.13). Approximately, Two percent of all dead seedlings showed the signs of leaf removal, while six percent of all dead seedlings had desiccated. The majority of seedlings assumed dead were disappeared from the bamboo tube.

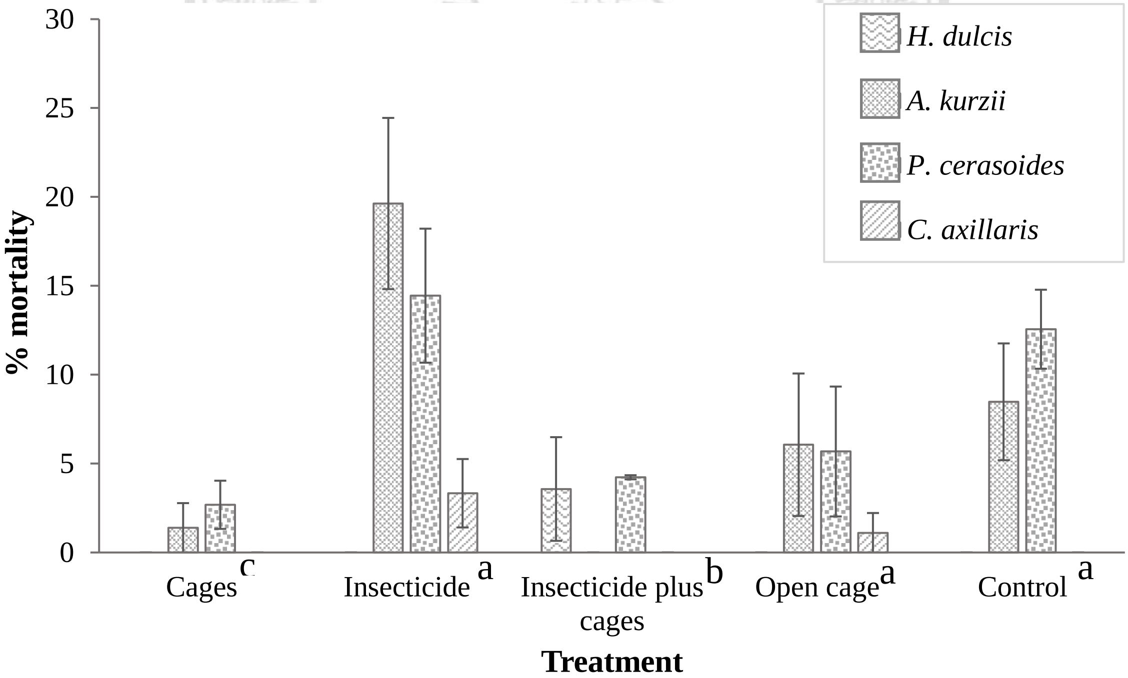

Figure 4.8 Actual percent cotyledonous-seedling mortality (±1SE) from the field data (three replicates of 30 seeds per replicate) of four tree species (*H. dulcis* ( ), *A. kurzii* ( ), *P. cerasoides* ( ) and *C. axillaris* ( )) calculated from total germination. Five treatments were categorized into groups according to the GLM. The letters (a - c) indicate significantly different proportions of cotyledonous-seedling mortality, compared with control treatment.

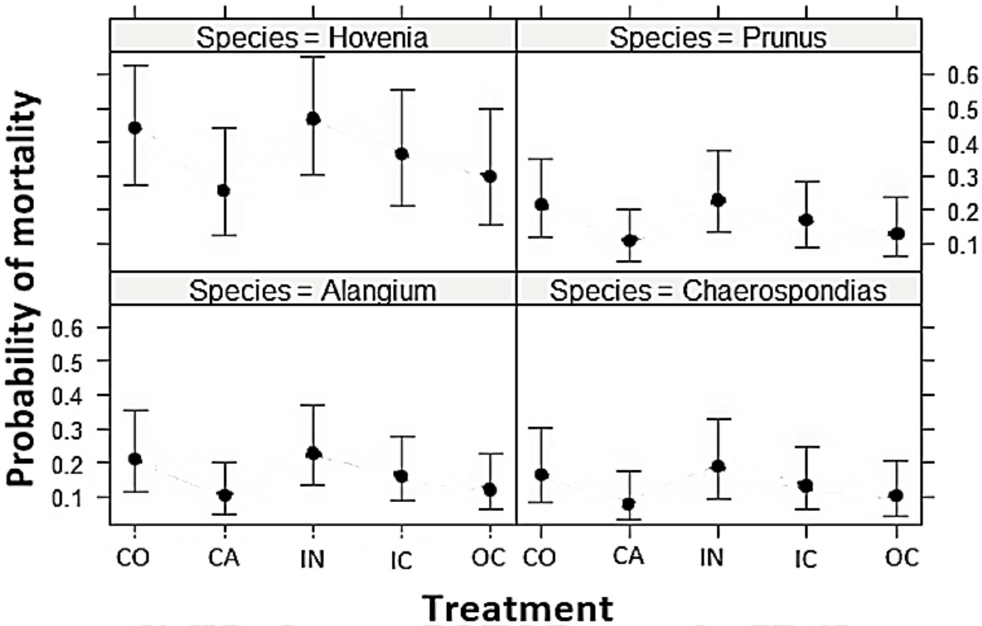

Figure 4.9 Effect plot represent the proportion of cotyledonous-seedling mortality predicted by GLM. Each panel shows a prediction of mortality probability (±1SE) for each tree species in five treatments, including CO (control), CA (cage), IN (insecticide), IC (insecticide plus cage) and OP (open cage).

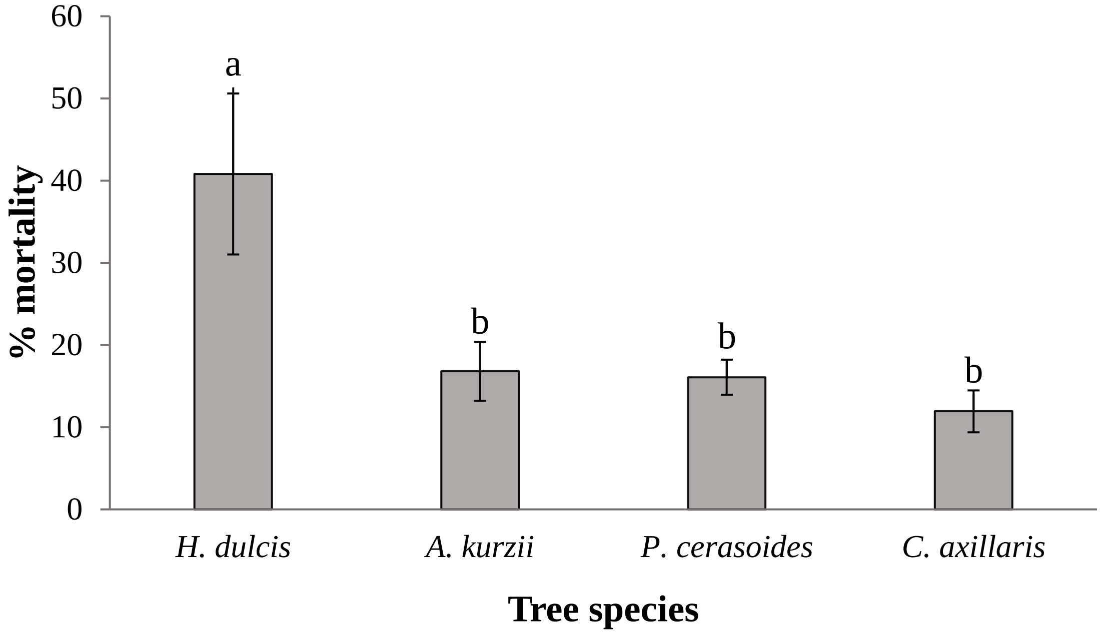

Figure 4.10 Actual mean percent leafy-seedling mortality (±1SE) of four tree species average over five treatments (30 seeds per replicate 0f three), calculated from total germination. The letters (a – b) indicated significantly different proportions of mortality, compared with *A. kurzii* species, estimated by the GLM (at p-value = 0.05).

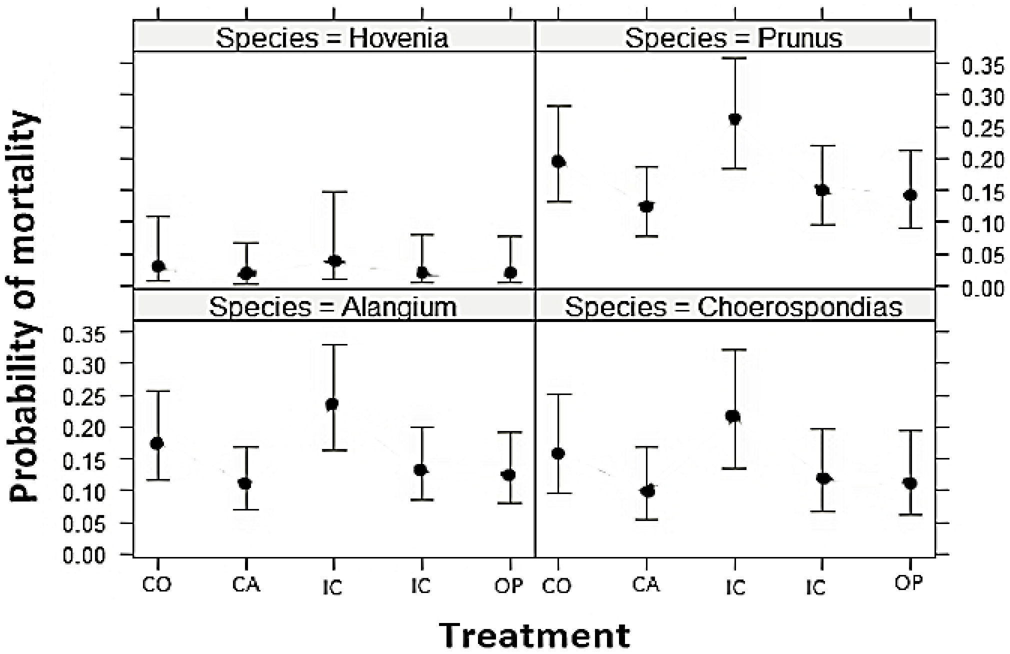

Figure 4.11 Effect plot represent the proportion of leafy-seedling mortality predicted by GLM. Each panel shows prediction (±1SE) of each tree species in five treatments including CO (control), CA (cage), IN (insecticide), IC (insecticide and cage) and OP (open cage).

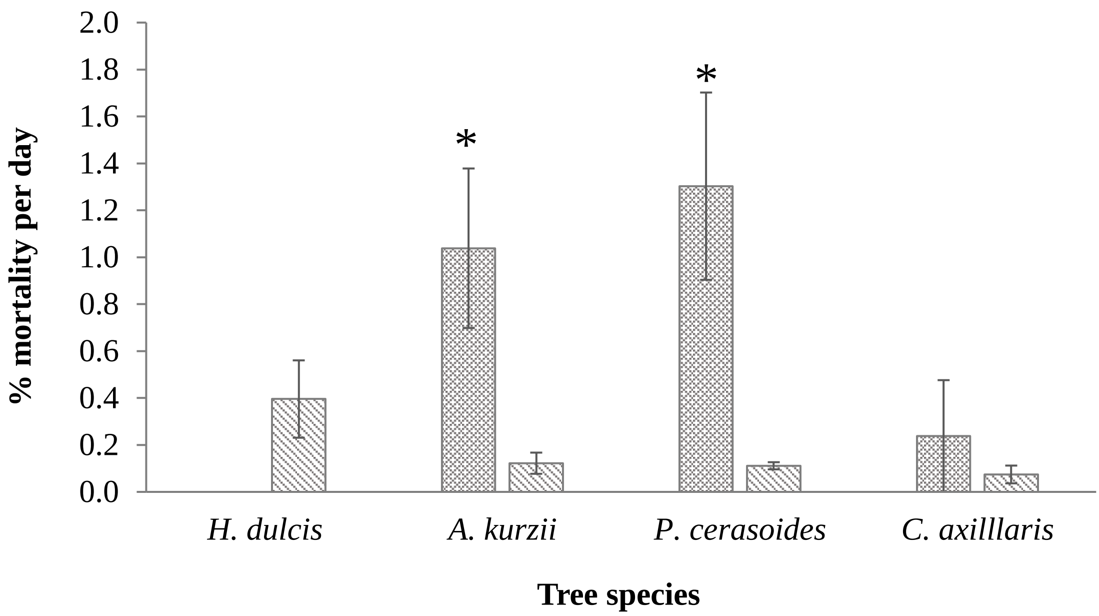

Figure 4.12 Comparing of percent mortality per day between cotyledonous-seedling ( ) and leafy-seedling stages ( ) of each species by t-test (at p-value less than 0.05), ***** represent significant higher percent mortality per day (total day: 7 days for cotyledonous-seedling and 139 days for leafy-seedling).

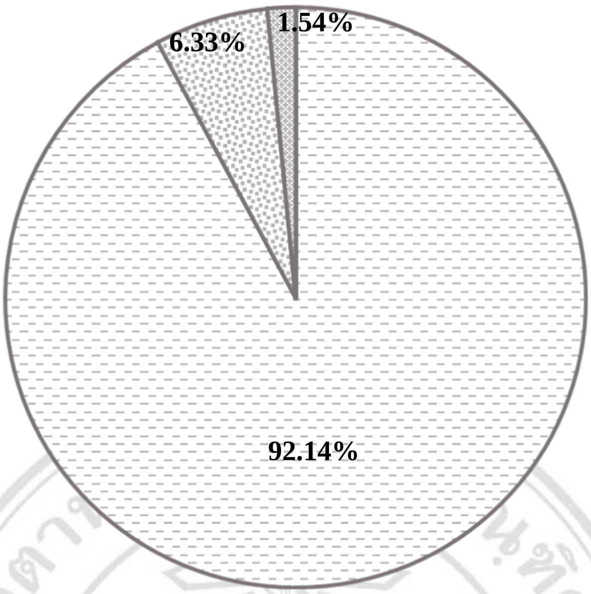

Figure 4.13 Three categories of physical appearance and percent of seedlings found. Percent cause of seedling mortality with only stem (▒), dry seedling (▒) and nothing can observed (▤).

4.4 Seedling survival

After the predator exclusion experiments had been terminated, seedling survival continued to be monitored until July 2016 (after dry season). The mean percent seedling survival ranged from 13.49 ± 8.29 percent (*H. dulcis*) to 56.74 ± 6.04 percent (*P. cerasoides*). The GLM showed that *P. cerasoides* and *C. axillaris* survived significant better survive than *A. kurzii* and *H. dulcis* did (Figure 4.14, appendix C). The mean predicted probability of survival of *P. cerasoides* and *C. axillaris* seedling was 0.58, while it was 0.22 in *A. kurzii* and *H. dulcis* (Figure 4.15).

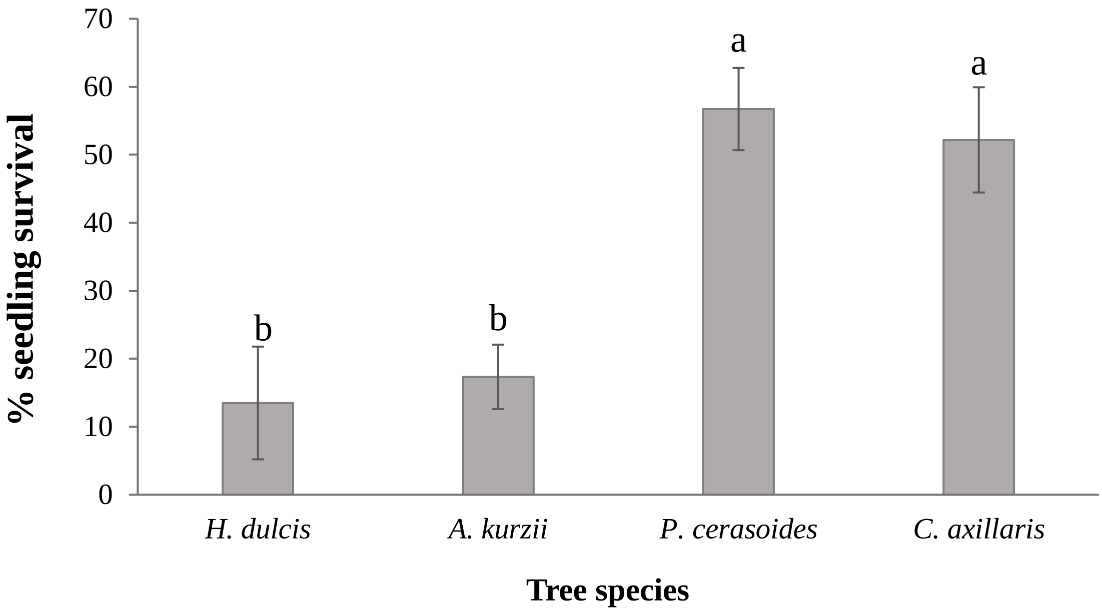

Figure 4.14 Observed mean percent seedling survival of four tree species; *H. dulcis A. kurzii*, *P. cerasoides*, *C. axillaris* and (10-month old seedlings). The letters (a - b) indicate differences in proportion of seedling surviving at p-value = 0.010 according to the GLM.

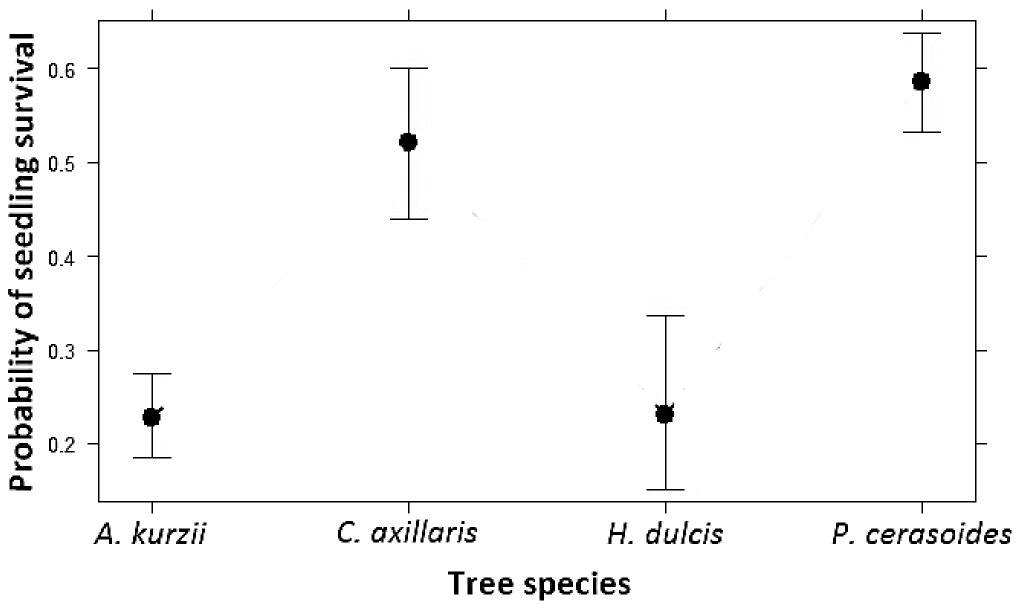

Figure 4.15 Effect plot represents the proportion of seedling survival (±1SE) predicted by the generalized linear model (GLM).

4.5 Growth and performance index

Among the species tested *P. cerasoides* seedlings grew the tallest, had the broadest crown (CW), and the largest root collar diameter (RCD) by the end of the study period. The relative growth rates (RGR) of each growth measurement varied among species. Using relative height growth, the fastest growing species were *P. cerasoides* and *C. axillaris*; the two species grew more than 450% per year (Table 4.1). For the relative CW growth, *C. axillaris* had the highest RGR. In contrast, despite its small size, *H. dulcis* had the highest relative RCD growth among the four species.

Relative performance score for the five tree species were calculated by combining nine parameters (see in Table 3.2). Only one species, *P. cerasoides*, was classified as an excellent species. The pioneer tree species, *P. cerasoides* had low seed removal, high seed germination and high survival and growth. *A. kurzii* and *C. axillaris* had good performance for direct seeding. *H. dulcis* was classified as a marginal species because of low germination and small seedling size. The species with the poorest performance *H. glabra* is not recommended for direct seeding.

Table 4.1 Mean growth measurements - height, crown width (CW) and root collar diameter (RCD) - and relative growth rate (RGR: percent per year) of the growth measurements. The growth of *H. glabra* was not available due to no seed germination and seedling establishment. .

Species name	N	Height		CW		RCD	
		Mean ± SE (cm)	%RGR (per year)	Mean ± SE (cm)	%RGR (per year)	Mean ± SE (mm)	%RGR (per year)
H. dulcis	15	15.57 ± 0.80	281.86	13.91 ± 1.61	287.77	2.17 ± 0.13	367.50
A. kurzii	73	16.41 ± 1.05	238.31	14.72 ± 1.14	184.48	2.93 ± 0.14	227.52
P. cerasoides	184	66.51 ± 5.19	457.22	29.84 ± 1.20	257.91	4.69 ± 0.23	222.40
C. axillaris	45	32.23 ± 3.00	458.68	23.41 ± 0.97	432.85	2.72 ± 0.15	181.10
H. glabra	-	-	-	-	-	-	-

Table 4.2 Summary of tree species performance score and classification based on direct seeding field (rating score: E (excellent), A (acceptable), M (marginal) and U (unacceptable)). (See Table 3.2 for definitions)

Parameters	***H. dulcis***		***A. kurzii***		***P. cerasoides***		***C. axillaris***		***H. glabra***	
	Score	***Rating score***	***Score***	***Rating score***	***Score***	***Rating score***	***Score***	***Rating score***	***Score***	***Rating score***
%Seed removal	4	E	4	E	4	E	4	E	1	U
%Seed germination	1	U	4	E	4	E	1	U	1	U
MLD	4	E	4	E	4	E	4	E	1	U
%Seedling mortality	2	M	3	A	3	A	4	E	-	-
%Survival (after dry season)	1	U	1	U	3	A	3	A	-	-
Height	1	U	1	U	4	E	2	M	-	-
CW	1	U	1	U	2	M	2	M	-	-
RCD	2	M	2	M	4	E	2	M	-	-
Average of RGR (%per year)	4	E	4	E	4	E	4	E	-	-
Species performance	20	**Marginal**	24	**Good**	32	**Excellent**	26	**Good**	3	**Poor**

4.6 Potential seed predators

a. Vertebrates species (Bird and small mammals)

Over the course of the seven months, each camera was installed for 200 trap days, for a total of 1,000 trap days over all. Fifteen animal species were detected in 116 photographs. The total number of animal photographs was highest in the first month. Among all the photographs, 54% were of two seed predator species: rat (*Rattus sp.*) and barred buttonquail (*Turnix suscitator*). Thirteen species of non—seed predators were also photographed, accounting for 46% of the total number of photographs.

Most animals visited the plots during the daytime whilst only 3 species, rat (*Rattus sp*.), hog badger (*Arctonyx collaris*), and the large Indian civet (*Viverra zibetha*) visited at night. Among the detected animals, rodents were detected more frequently than other small mammals and bird species (Table 4.3).

Table 4.3 Relative species occurrence in each month shown by the number of photographs per total effort 100 trap days (R) and the percentage of total (%). The number in parenthesis under the month name shows total trap days in each month of five cameras.

Scientific name	Common name	Aug (140)		Sep (175)		Oct (140)		Nov (140)		Dec (175)		Jan (140)		Feb (90)	
		Ni	R	Ni	R	Ni	R	Ni	R	Ni	R	Ni	R	Ni	R
Seed predator															
Rattus sp.	Rat	30	273	2	6	3	19	6	46	0	0	0	0	7	61
Turnix suscitator	Barred Buttonquail	18	72	1	1	0	0	0	0	0	0	0	0	0	0
Sum Predator		**48**		**3**		**3**		**6**		**0**		**0**		**7**	
% in month		**67.606**		**30**		**33.333**		**46.154**		**0**		**0**		**41.176**	
% in group (all month)		**71.642**		**4.4776**		**4.4776**		**8.9552**		**0**		**0**		**10.448**	
Non_Seed predator															
Anthus cervinus	Red-throated Pipit	0	0	0	0	1	4	0	0	0	0	0	0	0	0
Tupaia belangeri	Northern tree shrew	6	14	1	3	1	11	4	16	0	0	2	29	0	0
Canis aureus	Asia jackal	0	0	0	0	1	14	0	0	0	0	0	0	0	0
Centropus sinensis	Greater coucal	6	119	2	6	1	17	0	0	0	0	1	4	2	17
Herpestes javanicus	Small asian mongoose	2	7	1	3	1	11	1	4	0	0	0	0	3	8
Lanius schach	Long-tailed Shrike	0	0	0	0	1	4	1	4	0	0	0	0	1	4
Lonchura punctulata	Scaly-breasted Munia	0	0	0	0	0	0	0	0	0	0	0	0	1	11
Prionailurus bengalensis	Leopard cat	2	4	3	9	0	0	0	0	0	0	0	0	1	11
Phylloscopus trochiloides	Greenish Warbler	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Pycnonotus aurigaster	Sooty-headed bulbul	0	0	0	0	0	0	1	4	0	0	3	18	0	0
Saxicola caprata	Pied Bushchat	3	3	0	0	0	0	0	0	0	0	1	4	1	6
Arctonyx collaris	Hog badger	3	6	0	0	0	0	0	0	0	0	0	0	0	0
Viverra zibetha	Large indian civet	1	7	0	0	0	0	0	0	0	0	0	0	0	0
Sum Non_Seed predator		**23**		**7**		**6**		**7**		**0**		**7**		**10**	
% in month		**32.394**		**70**		**66.667**		**53.846**		**0**		**100**		**58.824**	
% in group (all month)		**38.333**		**11.667**		**10**		**11.667**		**0**		**11.667**		**16.667**	
	All	**71**		**10**		**9**		**13**		**0**		**7**		**17**	

b. Invertebrate species (Insects)

Collected invertebrates (insect) were classified into Order and Family. The total number of insect was 6,170 individuals from 73 families and 17 orders (Table 4.4). Species in Order Hymenoptera were the most commonly capture individuals out of a total of 3,544 individuals from 11 families. They were dominant in every period. Followed by Order Diptera (1,284 individuals, 13 families), Order Homoptera (398 individuals, 6 families) and Order Coleoptera (162 individuals, 8 families). Whereas, less than 100 number of individuals of other insect orders were caught representing few number of family.

Insects were divided to 3 groups according to their diet feeder (Table 4.4):-

Insect seed predators, included 3 Families from 3 Orders. Ant species (Order Hymenoptera; Family Formicidae) was the most dominant of this insect group. Other species were in family Curculionidae (Order Coleoptera) and Largidae (Order Hemiptera).

Insect plant feeders included 24 Families from 9 Orders. Thrips (Order Thysanoptera; Family Phlaeothripidae) was the most abundant for plant feeder group followed by Leafhoppers (Order Homoptera; Family Cicadellidae) and Aphids (Order Homoptera; Family Cicadellidae).

Other insect groups were predators of other insects, scavengers and parasitoids. This group comprised 42 families from 13 orders. Most of them were in the Orders Diptera and Hymeoptera.

They were classified into three groups according to their mouthparts, 1) chewing, 2) sucking and 3) lapping mouthpart. Sixty-one percent of collected families had chewing mouthparts from 36 families. Twenty and 19% of collected individuals had lapping and sucking mouthpart types, respectively (Figure 4.16).

The species composition of the insects captured varied among collection periods. Species richness, diversity and species evenness were highest all in August 2015, followed by October 2015 and dry season on April 2016 respectively (Table 4.4).

Sorensen's coefficient similarity index ranged from 0 (the lowest similarity between two communities) to 1 (vary high similarity between two communities or both communities are same). The insect community composition in August 2015 was more differ from April 2016 and October 2015 when compared among three months (Table 4.4). However, the coefficient range from 0.514 - 0.635 which is not much difference. This result can assume the insect community composition did not change much over the study period.

Table 4.4 Number of insect individuals on August 2015, October 2015 and April 2016 (Feeder: S (seed feeder/destroyer), P (plant feeder) and O (other insect or predator of other insects))

	Order	Family	Aug 2015	Oct 2015	Apr 2016	Feeder
1	Araneae	Araneae	6	22	21	O
2		Unknown	2	1	1	O
3	Blattodea	Blaberidae	1			O
4		Blatellidae		4	3	O
5		Unknown		8		O
6	Coleoptera	Carabidae	1	1		P
7		Chrysomelidae	1	2		P
8		Curculionidae	4	1	2	P/S
9		Leidodidae	1			P
10		Scarabaeidae	81			P
11		Schizopteridae			3	P
12		Staphylinidae	7	4		O
13		Unknown	42	10	2	O
14	Collembola	Entomobryidae	2	12	7	O
15	Dermaptera	Forficulidae	1	1		O
16		Unknown		1		O
17	Diptera	Calliphoridae	1			O
18		Cecidomyiidae		1		O
19		Chloropidae		1		P
20		Dolichopolidae	19			O
21		Drosophilidae	252			O

Table 4.4 (continued)

	Order	Family	Aug 2015	Oct 2015	Apr 2016	Feeder
22		Faniidae	1			O
23		Leptocera	12			O
24		Muscidae	8			O
25		Phoridae		1		O
26		Platystomatidae	2			O
27		Sarcophagidae	1			O
28		Tachinidae	2			O
29		Unknown	798	137	48	O
30	Hemiptera	Cimicidae	1			O
31		Largidae		1		P/S
32		Miridae		1	1	P
33		Pentatomidae			1	P
34		Reduviidae	2	3		O
35		Rhopalidae	1			P
36		Schizopteridae			2	O
37		Unknown	3	3	1	O
38	Homoptera	Aphididae	157	10	2	P
39		Cicadellidae	73	70	83	P
40		Cimcidae	1			P
41		Cixiidae (Nymp)	2			P
42	Hymenoptera	Apidae	1			O
43		Bethylidae	1			O
44		Braconidae	3			O
45		Ceraphronidae		2		O
46		Diapriidae		7		O
47		Evaniidae		1		O
48		Formicidae	733	1774	748	S
49		Ichneumonidae	1			O
50		Pompilidae		1		O
51		Tenthredinidae		1		O
52		Unknown	173	37	61	O
53	Isoptera	Termitidae	1	1	1	O

Table 4.4 (continued)

	Order	Family	Aug 2015	Oct 2015	Apr 2016	Feeder
54	Lepidoptera	Erebidae	2	4		P
55		Geometridae	25	13	4	P
56		Noctuidae	1			P
57		Unknown	5		2	O
58	Mantodea	Oligonychinae	1			O
59	Orthoptera	Acrididae	8	3	2	P
60		Gryliidae	3	16	9	P
61		Gryllotalpidae	5			P
62		Tetrigidae	6	4	6	O
63		Unknown	2	2	2	O
64	Phasmatodea	Heteronemiidae	1			P
65	Phasmida	Pseodophasmatidae			1	P
66	Strepsiptera	Corioxenidae		1		O
67	Thysanoptera	Phlaeothripidae	130	24	384	P
Total number of individuals			**2587**	**2186**	**1397**	
Number of species			**41**	**28**	**17**	
Shannon's diversity index			**1.418**	**0.362**	**0.408**	
Species evenness			**0.382**	**0.109**	**0.144**	

*Diversity index based on Shannon's method (Log base e)

Table 4.5 Sorensen's Coefficient similarity matrix (data log (e) transformed) showed the number of correspondences among insect community in tree month (calculated by number of individual in families).

	Aug-15	Oct-15	Apr-16
Aug-15	1		
Oct-15	0.552	1	
Apr-16	0.514	0.635	1

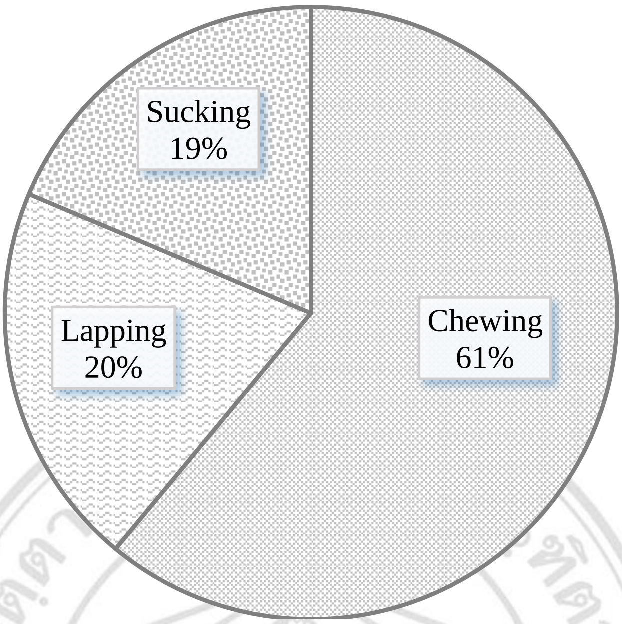

Figure 4.16 Proportion of insect families classified by mouthparts; chewing mouthparts ( ), lapping mouthparts ( ) and sucking mouthparts ( ).

4.7 Variation of animal visits and seed-seedling transitional stage

Vertebrates began visiting the plot two days after seeds were sown in August 2015. Of all seeds, 21.56% were destroyed and/or removed from the bamboo tubes from August through October. No seeds were destroyed and/or removed from November to February. Considering to seedlings, mortality peaked in September to October. The relative occurrence of individuals of seed predator and non—seed predator species visiting the plot varied from month to month. In other words, temporal variation in animal visits were observed in this field (Figure 4.17).

Invertebrates species recorded across three seasons fluctuated. Highest abundance was recorded in August and it declined in April. Insect seed predators were abundant in every season, but abundance was not related with seed-seedling stage. As same as insect herbivore, they were lowest in October, which the most of seedling emerged. So, variation of insect abundance and community composition in related with seed and seedling were still not clear (Figure 4.17).

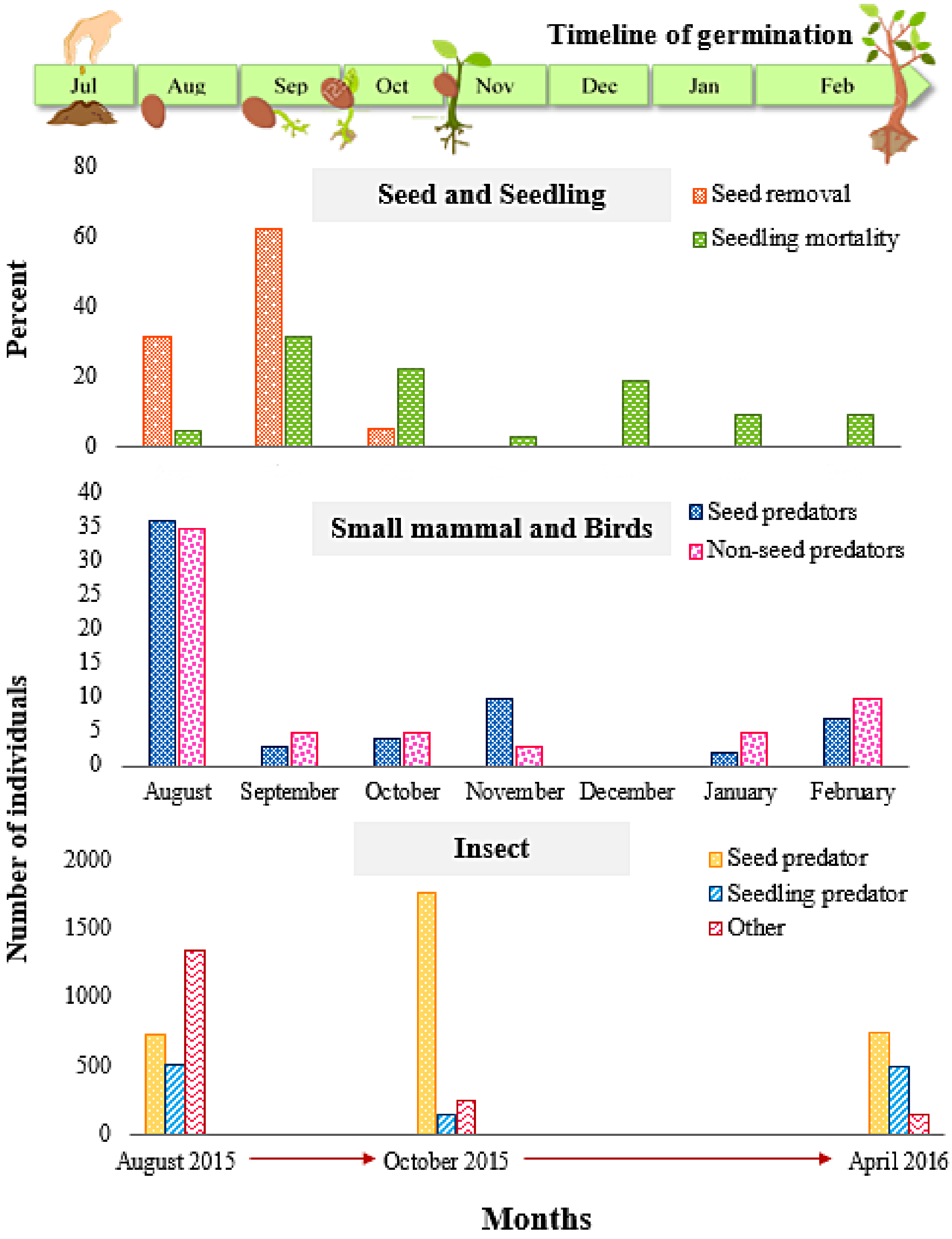

Figure 4.17 The correlation between number of small mammal and birds: seed predators (■) and non—seed predators (■) and number of insect: seed predator (■), seedling predator (■) and other insect (■) in related to each seed-to-seedling stage from August 2015 – February 2016.