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PHAM HUU HUNG

RESEARCH OF THE BIODIVERSITY AND THE CONSERVATION MEASURES OF THE BEETLE (COLEOPTERA) IN PU LUONG NATURE RESERVE, THANH HOA PROVINCE

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Science supervisors:

1. Prof. Dr. Nguyen The Nha - Vietnam National University of Forestry

2. Dr. Le Van Ninh –Hong Đuc university, Thanh Hóa province

Reviewer 1: .....

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Reviewer 2: .....

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Reviewer 3: .....

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1. Phạm Hữu Hùng, Nguyễn Thế Nhã, Lê Văn Ninh, Hoàng Thị Hằng (2019), Một số đặc điểm sinh học, sinh thái học loài *Serrognathue platymelus sika* Krieshe, 1920 (Coleoptera: Lucanidae) tại Khu bảo tồn thiên nhiên Pù Luông, tỉnh Thanh Hóa. *Tạp chí Khoa học và Công nghệ lâm nghiệp*, Trường Đại học Lâm nghiệp. Số 3-2019.

2. Phạm Hữu Hùng, Nguyễn Thế Nhã, Lại Thị Thanh, Hoàng Thị Hằng (2019), Đa dạng côn trùng họ Bọ hung (Coleoptera: Scarabaeidae) ở Khu bảo tồn thiên nhiên Pù Luông, tỉnh Thanh Hóa. *Tạp chí Khoa học và Công nghệ lâm nghiệp,* Trường Đại học Lâm nghiệp. Số 4-2019.

3. Phạm Hữu Hùng, Nguyễn Thế Nhã, Lê Văn Ninh (2019), Một số đặc điểm hình thái, sinh học và sinh thái học loài *Aceraius grandis* Burmeister, 1847 (Coleoptera: Passalidae) tại Khu bảo tồn thiên nhiên Pù Luông, tỉnh Thanh Hóa. *Tạp chí Bảo vệ thực vật*. Số 2-2019.

4. Phạm Hữu Hùng, Nguyễn Thế Nhã, Lê Văn Ninh, Lại Thị Thanh, (2019), Đặc điểm đa dạng sinh học các họ chính côn trùng bộ Cánh cứng (Coleoptera) tại Khu bảo tồn thiên nhiên Pù Luông, tỉnh Thanh Hóa. *Tạp chí Nông nghiệp và Phát triển nông thôn.* Số 13-2019.

INTRODUCTION

1. The need of the thesis

In the species composition, the beetle (Insecta, Coleoptera) is diverse and abundant, so it has the largest number of species in the insect class. According to Hammond (1992), about 40% of the described insects belong to the beetle. It is estimated that there are over 500 species of insects, belonging to 260 genera, 70 families used as dairly food for human with highly nutritional value, mainly in the larva stage and pupae, in which there are about 344 species of beetle. Beetles play an important role in controllability, pollination for plants, dispersing seeds, and adjustment of the number of harmful organisms such as carnivorous beetle of the Coccinellidae or the Carabidae family. In recent years, forest area and its quality have been degrading, and the habitat for beetle has been also severely dividing or destroying, leading to many species of useful beetle are reduced in number, and dealed with the danger of extinction.

The tatal area of Pu Luong Nature Reserve (NR) is about 17.171,03ha, in which the rigorous protection zone, the ecological rehabilitation zone, are about 12.561.6 ha, is 4,300.04 ha, respectively. The rest ones are the administrative and servicing subdivisions . in fact, the research on insect fauna in Pu Luong Nature Reserve, especially the study on beetle is insufficient. Present researches were mostlygeneralized and conducted in small scopes, with short sampling time, while the life cycle of some species of beetle are quite long. Therefore, the list of species composition and biodiversity characteristics have not been fully updated, and there are no specific and suitable measures in the conservation and development of the beetle. For the abovementioned reasons, we carried out the thesis, it is named "Research on biodiversity and conservation measures of the beetle (Coleoptera) in Pu Luong Nature Reserve, Thanh Hoa province".

2. Research objectives

- To identify the species composition and structure composition characteristics of some beetle families.
- To assess the species diversity of some beetle families in Pu Luong Nature Reserve
- To find out y some biological and ecological characteristics of subspecies Serrognathue platymelus sika Krieshe, 1920 and species Aceraius grandis Burmeister, 1847.
- To propose some suggestions and recommentations for protection and development of the beetle in Pu Luong Nature Reserve.

3. Scientific and practical significance of the thesis

Scientific significance: The thesis provides new, systematic data of the beetle composition and its biodiversity in Pu Luong Nature Reserve. In addition, the dissertaion is the first scientific documment, which thesis provides scientific information of the biological and ecological characteristics of a number of value species conservation. It may be considered as a scientific documment to propose different technical measures for conservation, and sustainable development of species of beetle, that has conservation value in Pu Luong Nature Reserve.

Practical significance: Supplementing information as a scientific documment for the planning, conservating projects, management, and rational use of biological resources in general and the beetle in particular. The measures of conservation and development of the beetle species proposed by the thesis are specific guidelines to support the Management Board of Pu Luong Nature Reserve to carry out the biodiversity conservation management activities in Pu Luong Nature Reserve.

4. New contributions of the thesis

- 171 species of beetle have been recorded and a list of 193 species of beetle belonging to 146 genera and 28 families has been determined, in which, 144 of new species have been added to the beetle fauna in Pu Luong Nature Reserve. Furthermore, the thesis also provides scientific data of biodiversity of beetle in Pu Luong Nature Reserve.

- Providing new information of biological and ecological characteristics of subspecies *Serrognathue platymelus sika* and species *Aceraius grandis.*

- The thesis has suggested a list of 37 species of the beetles for priority conservation, and some conservation measures of the beetle fauna in Pu Luong Nature Reserve, Thanh Hoa province.

CHAPTER 1. LITERATURE REVIEW

1.1. Overview of research situation in the world

1.1.1. Composition and distribution characteristics of the beetle

According to Lawrence (1995), about 400,000 species of beetle have been identified in the world, accounting for about 40% of the total number of insects, with 167 families, and 450 subfamilies. Nielsen and Mound (1999) also estimated that approxiamation of 300,000 and 450,000 species of beetle have been described. The resrearch conducted by Andrés and Francisco (2008) showed that there were about 1,000 species of beetle, belonging to 53 families at Fragas del Eume National Park, Spain. with . Those families had more than 10 species including: Carabidae, Curculionidae, Chrysomelidae, Staphylinidae, Scarabaeidae, Cerambycidae, Dytiscidae, Nitidulidae, Hydrophilidae and Coccinellidae. The families with a few of species were Byturidae, Anthribidae, Anobiidae and Alleculidae. According to Bouchard et al., (2009), in the 358,000 of beetle species belonging to 165 described families, there were about 62% of the species in 6 families, they had the largest number of species (over 20,000 species) including: Curculionidae, Staphilinidae, Chrysomelidae and Carabidae family.

S'lipiński *et al.* (2011) reported that there are about 386,755 species of the composition of beetle belonging to 5 suborders, in which the Polyphaga suborder has 7 series including: Staphyliniformia, Scirtiformia, Scarabaeiformia, Elateriformia, Derodontiformia, Bostrichiformia, and Cucujiformia. The most species of beetle belong to the Polyphaga with 165 families, 27.736 genera, and 380.146 species accounting for 79,3%, 93,3%, and , 98,2% respectively. The least diverse is the suborder of Protocoleoptera , it has only 7 families, 48 genera, and 112 species accounting for 3,4%, 0,16%, and 0,03% respectively.

1.1.2. Research of the diversity, biological and ecological characteristics of beetle

According to Vanesca et al. (2013), there were 59 species, 17 genera in the Amazon rainforest, in which the forest ecosystem had the highest number of species and dominant species. Dufrene & Legendre (1997) and Mc Geoch et al., (2002) used *IndiVal* Index to determine the biological indicator of beetle. Bhargava et al., (2009) also used IndiVal index to calculate the habitat indicator of beetle species of 5 families, including: Carabidae, Cicindelidae, Scarabaeidae, Staphylinidae and Cerambycidae.

The diversity of beetle in different habitats is determined by biodiversity indicators, presenting the adaptability of beetle to habitat, food sources, climate, geography as well as biological and ecological characteristics of beetle. Many scientists have studied in the detail of the biological and ecological characteristics of beetle such as McHugh et al., (2009), Sformo et al., (2010), Hodek (2012), Crowson (2013).

1.1.3. Research of the fundermental conservation of beetle in the world

Martin et al., (2000) proposed a number of considerations for conservation as maintaining a diversity of soil substrates such as litter, fresh vegetation, hydrology, and successional age. in order to protect biodiversity, a representative sample of habitats should be preserved. Continueously, producing a highly dynamic area with different habitats, It is the key factors that determine diversity of the beetle.

Cheong (2011) suggested the solution forbeetle conservation beetle are maintaining mixed natural forests, forest litter, planting additional species of flowers, grass, and shrubs. further more, management and maintaining the surplus raw materials such as branches from large trees in a natural or semi-natural direction to generate an suitable environment for beetle movement, searching food, copulation, and residence.

New (2010) mentioned that the role of habitat, characteristics of environment, topography, falling materials and interaction between native beetle to alien species are the threats to beetle. In the conservation field , the author focused on the offsite conservation form, investigation and identification of new species, strengthening the management, prevention from harmful species, rescue and raising of useful species. The challenges in conservation are forest fire, the changes in species composition, fluctuations in insect population density, , and restoration of insect habitats -. Protected forests are a suitable environment for the conservation of endangered species, including large size species such as *Heliocopris gigas, Catharsius molossus, C. sagax, C. pithecius, Copris repertus, C. surdus, Paragymnopleurus sinuatus* and *Onthophagus bengalensis*. These species have not been presented for along time in the delta regions, but still occur in the protected forests. Bouchard et al., (2017) identified that there are 791 species of beetle appeared on the IUCN Red List (2015), in which 12 are listed as extinct, 17 as critically endangered, 47 as endangered, and 45 as vulnerable.

1.2. Overview of the research situation in Vietnam

1.2.1. Study on species composition and distribution characteristics of beetles

Trần Công Loanh and Nguyễn Thế Nhã (1997) divided the order of beetle into 2 sub-order.The first one is the suborder of Adephaga, and the second one is Polyphaga. The prevailing families in forest ecosystems were Cerambycidae, Elateridae, Scarabaeidae, Curculionidae, Coccinellidae, Buprestidae, Histeridae, Ipidae, and Platypodidae. Research results from Dang Thi Dap and Tran Thieu Du (2003), (2013), Pham Quang Thu et al., (2010), Hoang Vu Tru et al., (2011), Jürgen et al., (2013), Vu Van Lien et al,. (2014), Pham Thi Nhi et al., (2015), Cao Thi Quynh Nga et al., (2014, 2015, 2017), and Le Bao Thanh (2017) have added many significant data of the composition of the beetle fauna in Vietnamese forest ecosystems. The results also showed that the distribution of beetle is counted on each habitat, food, habitats, natural enemies, topography, altitude, climate.In addition, the distribution of beetle is also depended on time and season of the year.

1.2.2. Research of the diversity, biological and ecological characteristics of the beetle

The researches carried out by Ta Huy Thinh et al., (2005), Hoang Duc Nhuan (2007), Nguyen Thi Viet et al., (2011), Nguyen Quang Cuong et al., (2014), Le Anh Son (2016), Le Thi Dien et al., (2012) are a typical example to assesse the diversity, and to add the composition of beetles in Bach Ma National Park. Vo Van Phu (2015) identified that 521 insect species belong to 357 genera, 69 families, 9 orders in the forest ecosystem of Cao Muon, and Ca Dam, Quang Ngai Province, among them, 13 families belong to the order of beetle.

In addition, the results of the study conducted by Fujita (2010), and Thai N. Q. (2013) identified that there are some new species of Lucanidae family. The researches of Do Manh Cuong (2014, 2015, 2017) defined that there are new species of the Cerambycidae family.

1.2.3. Research of the conservation facilty of beetle in Vietnam

Pham Binh Quyen (2005) divided insect into 7 life forms, including: underground insects, ground insects, litter insects, grass insects, trees and shrubs insects, dry wood insects, and water insects. Beetles have the largest number and composition of species in class of insects, so that they appear in all 7 life forms.

The Vietnamese Red Book of 2007 promulgated the ranks and standards of IUCN for different and at the levels as follow: extinction, wild extinction , critical endanger, endanger, vulnerability, lower riskness, inadequate data and none evaluation. In which, beetle had 10 species, which belongs to Lucanidae and Scarabaeidae families. In addition, - The Vietnamese govornment also proclaimed the specific regulations such as: the Decree 160/2013/ND - CP dated 12/11/2013, the Decision 11/2013 / QD -TTg dated 01/24/2013, the Circular 04/2017/TT-BNNPTNT dated 24/02/2017, and the Decree 06/2019/ND-CP for the management and conservation of the rare wildlife and plants.

1.3. Studies of beetles in Pu Luong Nature Reserve

The project implemented in 2013 for determination of the flora and fauna in Pu Luong Nature Reserve identified that there are 347 insect species belonging to 237 genera, 80 families, and 17 orders. In which, beetle has 49 species, accounting for 14,12%, belonging to 16 families accounting for 20,0%, with 41 genera, accounting for 17,29%. Cerambycidae family has the highest number of species (accounting for 20,41% of the total species), the number species of both Carabidae and Scarabaeidae families account for 12,24% of the total species, afterwald descend in the order of Curculionidae, Chrysomelidae, Meloidae, and Buprestidae, Coccinellidae, Lucanidae families. Tenebrionidae and Psephenidae had only 2 species, accounting for 4,08% of the total species. All of the Dytiscidae, Elateridae, Lampyridae, Histeridae, and Staphylinidae families had only 1 species, accounting for 2,04% of the total species.

Generally, the specific identification of species for conservation, measurements of conservation, and development of beetles in Pu Luong Nature Reserve is still not sufficient. There for, it is need to conduct a study of diversity, conservatiev measurements, and development of valuable beetle species in order tocontribute to the sustainable development of forest resources.

CHAPTER 2 CONTENTS AND RESEARCH METHODS

2.1. Research contents

2.1.1. Investigation of the beetle species composition in Pu Luong Nature Reserve

- Determinate the beetle species composition in Pu Luong Nature Reserve;
- Evaluate the characteristics of the structural species composition of some families in order of beetle;
- Study the distribution of taxon by the habitat, season and altitude.

2.1.2. Research of species diversity of some families in order of beetle in Pu Luong Nature Reserve

- Identify the species diversity characteristics in different habitats, seasons and altitudes
- Detect the indicator species by habitats;
- Propose some value species for conservation and development .

2.1.3. Study some biological and ecological characteristics of subspecies Serrognathue platymelus sika and species Aceraius grandis

2.1.4. Assessment of the current situation, and provided suggestions for conservation, and development measures beetle in Pu Luong Nature Reserve

2.2. Methodology

2.2.1. Determination of the composition of beetles methods

2.2.1.1. Habitat type identification

The dissertation has identified 6 main habitat types (SC) in the study area, including: SC 1 – the primary forest; SC 2 – the secondary forest; SC 3- the secondary grassland: SC 4 - the shrub scrub intergrating the secondary timber tree: SC 5 – the bamboo forest; SC 6 – the Arounding villages and swidden field

2.2.1.2. Making investigation routes and survey points

5 investigation routes have been made: Route 1: The Hieu-Khuyn-Eo Dieu village - Thong Pa Co peek; Route 2: The Cao - Son - Ba - Muoi village; Route 3: The Kho Muong, Thanh Cong - Kem - Doc Quyt village; Route 4: The Dong Diem village - Pu Luong peak; Route 5: The Bang - Tom village.

2.2.1.3. Methods of sampling investigation

- Collecting by net
- Collecting by traps: two different trap types were used: pitfall traps and flight interception traps
- Direct collection lyfrom where has fallen trees and dead trees

- Collecting beetle under the ground

2.2.1.4. Examination and preservation of specimens

2.2.1.5. Identifing the specimens

2.2.1.6. Methods ofthe identification of main families and suggestions for conservation of priority species

2.2.2. Evaluation of species diversity method

- The diversity is assessed by using the Shannon-Wiener (H') diversity index, the Simpson index, the Margalef index, the uniformity (E_H), and Sorensen similarity index (SI).

- Assessing indicator species by applyingthe formula: IndiVal = A_{ij} * B_{if} * 100.

2.2.3. Research methods of biological and ecological characteristics

Study some morphological, biological and ecological characteristics.

2.2.4. Methods of assessment of the current status, and proposing the measurements for conservation, and development of the beetle in Pu Luong Nature Reserve

2.2.5. Method of data processing

+ Using MS - Excel and SPSS softwares to analyze data of the composition, and diversity of beetle species; data of morphological, biological and ecological characteristics of 2 studied beetle species.

+ Using PAST Statistics (Hammer et al. 2001) to analyze the coefficients of beetle composition among habitats.

CHAPTER 3. RESULTS AND DISCUSSIONS

3.1. The composition of beetle species in Pu Luong Nature Reserve

3.1.1. The list of beetles species in Pu Luong Nature Reserve

Thestatistical results from the investigations have recorded that there are 171 species of beetles, including 45 prevailing species, 83 less popular species, and 43 random species. According to the report of the Management Board of Pu Luong Nature Reserve (2013), 49 species were recorded , in which 27 species were found to duplecate with the results of this study investigation, and 22 species had not been appeared in those surveys. Along with 49 species identified according to 2013 survey results, presently, the total number of beetles species recorded in Pu Luong Nature Reserve is 193 species, which belongs to 146 genera, 28 families, and there are only 23 new species identified to taxon genus. Through these surveys for this thesis, 144 species belongs to 25 families have added a new record for the beetle fauna in Pu Luong Nature Reserve. .

In Pu Hu Nature Reserve of Thanh Hoa province, there were 43 species also found, and coincided with Pu Luong Nature Reserve,.The unfound species in Pu Luong Nature Reserve are *Campsosternum sp.* and *Clivina biolatus*. Thus, in the total of 193 beetle species in Pu Luong Nature Reserve, 150 species have not been recorded in Pu Hu Nature Reserve. The number of taxon in Pu Luong Nature Reserve compared to other special-use forests is shown in Table 3.2.

Pu Hu Nature Reserve covers an area of 22.688,37 ha, in which, the area of rich forest, bamboo forests , are about 373,28 ha, and3.698,25ha, respectively.Most of the secondary forest area in the buffer zone is the restored forests after shifting cultivation and plantations, therefore, the beetle component is simple. The proportion of taxons in Pu Luong Nature Reserve is higher than Pu Hu Nature Reserve, but lower than Cuc Phuong National Park.

The area of Ba Be National Park is about 7,610ha, making up 43.5% in comparasion with the area of Pu Luong Nature Reserve, and its position isisolated from the Pu Luong Nature Reserve. The percentage of families, genera and species in Ba Be National Park is only equivalent to 75%; 55%, and 51,8% respectively, in comparasion with Pu Luong Nature Reserve.

Table 3.2. The comparasion of the taxon of the beetle wings in Pu Luong Nature Reserve with special use forests of Pu Hu, Cuc Phuong, and Ba Be.

Special-use forests	Family		Genus		Species	
	Quantity	**Ratio (%)**	**Quantity**	**Ratio (%)**	**Quantity**	**Ratio (%)**
Pu Luong Nature Reserve	28	100	146	100	193	100
Pu Hu Nature Reserve	17	60,7	39	26,2	45	23,3
Cuc Phuong National Park	36	128,6	192	128,8	454	235,2
Ba Be National Park	21	75,0	82	55,0	100	51,8

Among 100 beetle species in Ba Be National Park, Bac Kan province only 11 species are presented in Pu Luong Nature Reserve. The reasons are due to the difference from the distribution of species related to the geographical location, and the plant composition. Moreover the area of Pu Luong Nature Reserve is larger than Ba Be National Park, and the survey in Ba Be National Park is done in a short time. Thus, it is indicated that the geographic location, the area, habitat characteristics as well as the plants composition have an influence on the composition of taxon of the beetle.

3.1.2.The Structure of beetle components in Pu Luong Nature Reserve

3.1.2.1. The Structure of 28 beetle families

The investigated results in Pu Luong Nature Reserve have identified that there were 28 families belonging to the beetle order , but the number of genera and species are not equal among them. This clearly shown the separated ability to adapt to the different habitats of each family. Statistical results identified that each species has an average of 6,8 species, and 8 families have a larger number of species than the average value of species/family (6,8 species), including: Scarabaeidae, Cerambycidae, Carabidae, Chrysomelidae, Coccinellidae, Curculionidae, Tenebrionidae, and Lucanidae. These 8 families have 148 species, accounting for 76,68% of the total number of appeared species in the study site. Other families (the rests of 20 families) have 45 species, accounting for 23,32%, in which the family Anthribidae, Cucujidae, Eucnemidae, Eulichadidae, Histeridae, Lampyridae, and Pyrochroidae have only one species, accounting for 0,52%.

3.1.2.2. The structure of taxon components of major families

The analysis results show that there were 6 major families including 88 genera, accounting for 60,27%, and 122 species equivalent to 63,21% of the total number of species in Pu Luong Nature Reserve in comparasion with the total number of taxons., . The rest families have 58 genera, accounting for 39,73% with 71 species, making up 36,79% (Table 3.4). Among the 6 major families, the highest number of genera and species are the Scarabaeidae, and the lowest number belongs to Lucanidae.

Table 3.4. The structure of species composition of 6 major families in Pu Luong Nature Reserve

TT	**Family name**	**Genus**		**Species**	
		Quantity	**Ratio (%)**	**Quantity**	**Ratio (%)**
1	Scarabaeidae	25	28,41	37	30,33
2	Cerambycidae	19	21,59	25	20,49
3	Carabidae	16	18,18	23	18,85
4	Coccinellidae	10	11,36	16	13,11
5	Curculionidae	13	14,77	14	11,48
6	Lucanidae	5	5,68	7	5,74
Total		**88**	**100**	**122**	**100**

3.1.2.3. The distribution of the beetle taxon by the habitat

● *The distribution of 28 beetle families by habitats in Pu Luong Nature Reserve*

The component structure of family, genus and species by habitat (SC) is shown in Table 3.5. The distribution of taxons by habitats was different, if arrangment of the occurrence of taxons in descending orderthen ing the family taxon is descended in order of SC 4, SC 2, SC 3, SC 6, SC 1, and the lowest in SC 5. In genus taxon, the order was descended as follow: SC 4, SC 2, SC 6, SC 1, SC 5, and SC 3, while for the species taxon, the descending in the order of SC 4, SC 2, SC 6, SC 1, SC 3, and lowest in SC 5.

Table 3.5. Taxon distribution of the beetle by habitats

TT	Sinh cảnh	Family		Genus		Species	
		Quantity	Ratio (%)	Quantity	Ratio (%)	Quantity	Ratio (%)
1	Primary forest (SC1)	21	75	102	69,86	130	67,36
2	Secondary forest (SC2)	27	96,4	128	87,67	163	84,46
3	Secondary grassland (SC3)	24	85,7	70	47,95	95	49,22
4	Shrub scrub intergrating with the secondary timber tree (SC4)	28	100	138	94,52	177	91,71
5	Bamboo forest (SC5)	19	67,9	74	50,68	91	47,15
6	Around villages and swidden field (SC6)	22	78,6	114	78,08	152	78,76
Common taxon in all 6 SC		**28**	**100**	**146**	**100**	**193**	**100**

Taxon distribution of 6 major families by habitats

- The Primary forest: Among the 6 major families, the most diversity of family and genus was the Scarabaeidae. The next one was Carabidae. The Cerambycidae and Curculionidae had the same number of genus, but the number of species of Cerambycidae was larger. Similarly, the Coccinellidae and the Lucanidae also had the same number of genus, but the number of species of Lucanidae was larger.

- The secondary forest: due to the abundant litter and rotten wood branches, the Scarabaeidae was the most dominant family, and following by the Cerambycidae, Carabidae, Curculionidae, Lucanidae, and Coccinellidae, respectively.

-The secondary grassland: Becuse of no diversity in the plant composition, so that the beetle composition in this habitat type was the least diverse. Among the 6 main families, the most diverse was the Scarabaeidae family, following by the Cerambycidae, Carabidae, Coccinellidae, Curculionidae, and the Lucanidae species was not presented in this habitat.

- The shrub scrub intergrating with the secondary timber tree: beetle in this habitat was more diverse than other habitats, the Scarabaeidae familywas the mostprevailing, following by the Carabidae, Cerambycidae, Curculionidae, Coccinellidae, and the Lucanidae family.

- The bamboo forest: Due to the plant composition, and the stratum structurein in this habitat type is simple, and , the layer of rotten vegetation, branches, dead wood was poor, there is no diversity of beetle species composition was found. The species of the Cerambycidae family was the most dominant, following by the Curculionidae, Scarabaeidae, Carabidae, Coccinellidae, and the Lucanidae species had not been occured in this habitat.

- Arounding the villages and swidden fields: Scarabaeidae family had the largest number of genera and species, following by Cerambycidae, Curculionidae. All of the genera of the Coccinellidae and Curculionidae

families that appear ed in all 6 habitats also presented in this habitat, and the Lucanidae was not detected in this habitat.

3.1.2.4. The composition structure of 6 major families by seasons

The results fromidentification of 6 major beetle families in Pu Luong Nature Reserve (table 3.8) show that, the number of species and genera in the mature phase were varied seasonally in different habitats.

Table 3.8. The distribution of seasonal taxons

Order	Family	Taxons	Rainy season		Dry season	
			Quantity	Ratio (%)	Quantity	Ratio (%)
1	Carabidae	Genera	14	87,5	13	81,3
		Species	17	73,9	16	69,6
2	Cerambycidae	Genera	13	68,4	13	68,4
		Species	16	64,0	16	64,0
3	Coccinellidae	Genera	8	80,0	8	80,0
		Species	14	87,5	14	87,5
4	Curculionidae	Genera	8	61,5	8	61,5
		Species	9	64,3	9	64,3
5	Lucanidae	Genera	5	100	4	80,0
		Species	7	100	6	85,7
6	Scarabaeidae	Genera	23	92,0	18	72,0
		Species	32	86,5	26	70,3

The number of species appeared in the rainy season fluctulated from 30 species, accounting for 24,6% in the secondary grasslands to 80 species, making up 65,6% in the shrub scrub intergrating with the secondary timber tree. In the dry season, the number of species were changed from 16 species, accounting for 13,1% in the secondary grasslands to 57 species, accounting for 46,7% in the habitat arounding the village and swidden fields. The number of genera in the rainy season were varied from 23 genera, accounting for 26,1% in the secondary grasslands to 64 genera, accounting for 72,7% in the shrub scrub intergrating with the secondary timber tree. In the dry season, the number of genera were fluctulated from 13 genera, accounting for 14,8% in the secondary grasslands to 45 genera, accounting for 51,1% in the shrub scrub intergrating with the secondary timber tree.

In all of 6 habitat types, in the rainy season the number of genera was larger than in the dry season, and the fluctulated number of genera in the habitats were ranged from 8 to 19 genera, the highest fluctulation was 19 genera in the shrub scrub intergrating with the secondary timber tree. The disparity in genera were decreased in the order of SC6, SC1, SC2, SC3, and SC5 associating with the number of genera of 16, 15, 14, 10, and 8. The number of species in all 6 habitats presented in the rainy season was larger than in comparasion with the dry season, and ranged from 10 to 25 species., The highest was in shrub scrub intergrating with the secondary timber tree.; The number ofappeared species in the rainy season was larger than the dry season about 25 species. The disparity in the number of species was decreased in the order of SC2, SC6, SC1, SC3, SC5 corresponding to the number of species of 23, 20, 19, 14, and 10, respectively.

Table 3.8 shows that there was not difference of the number of genera and species among the Cerambycidae, Coccinellidae, and the Curculionidae in in the year. In the two seasons, there was only only one species less than the other between the Carabidae and the Lucanidae families are , named *Scarites terricola*. The Scarabaeidae family had a large disparity in the number of genera and species between the two seasons. Particularly, the number in the rainy season had much more than the dry season with 5 genera and 6 species.

3.1.2.5. The structure of species composition of 6 major families by the altitude

The statistical results show that there were 89 species with a wide distribution range. The Scarabaeidae family had 29/37 species (accounting for 78,4%) with widely distributed range. The ratios of the families of

Curculionidae, Carabidae, Coccinellidae, and Cerambycidae were about 64%, 65,2%, 81,2%, and 64,3%, respectively. The species of Lucanidae family spreaded in the both elevations.

Species with narrow distribution, there were 95 species spreaded at elevation under 700m , 91 species were distributed at higher 700m above sea level. The different number of species by the latitude was not clear.,This were only 4 species appeared at elevations under 700m but not occured at altitudes above 700m, in which Scarabaeidae had 3 species: the *Allissonotum sp. Onthophagus kindermanni* Harold, the 1877, and the *Protaetia fusca* (Herbst, 1790), and the Coccinellidae family had only 1 species, namedthe *Epilachna* sp.

The statistics of 6 major taxon families show that the number of species and breeds distributed at elevations under the latitude of 700m much higher than s above elevation of 700m. In shrub scrub intergrating with the secondary timber tree, secondary grassland, and primary forest were 23, 18, and 3 species, respectively.

3.2. The diversity of beetle species in Pu Luong Nature Reserve

3.2.1. The species diversity of 6 major beetle families

The species diversity of 6 major beetle families is shown in Table 3.13.

Table 3. 13. Species diversity index of 6 major families

Order	Families	Diversity index			
		H'	**1-D**	**d**	**Similarity index (E_H)**
1	Carabidae	2,78	0,94	2,69	0,98
2	Cerambycidae	2,59	0,90	2,49	0,93
3	Coccinellidae	2,58	0,92	2,21	0,98
4	Curculionidae	2,09	0,87	1,45	0,95
5	Lucanidae	1,91	0,85	1,3	0,98
6	Scarabaeidae	3,40	0,97	4,71	0,98

According to the Table 3.13, the Scarabaeidae had the highest values of H, 1-D, and d index, while Lucanidae was the lowest values of H, 1-D. The similarity index E_H was not much fluctuation, the highest was the Carabidae family (E_H = 0,98), the lowest in belonged to the Cerambycidae (E_H = 0,93). Among 6 major families, the Scarabaeidae family had the highest diversity. The diverse indices of 3 families, including: Carabidae, Cerambycidae, and Coccinellidae were not significantly different. The diversity indices of the Curculionidae family were significantly lower than the abovementioned families, and the least diverse belonged to the Lucanidae family.

3.2.1.1. The species diversity of 6 major families by habitat

Species diversity index of 6 major families in each habitat is shown in Table 3.15. The highest index were Shannon index with the H' value = 4,32 in shrub scrub *intergrating with the* secondary timber tree, and the lowest H'valua = 3,31 in secondary grassland.

Table 3. 15. The species diversity index of 6 major families by habitats

TT	Habitat	Diversity index			
		H'	**1-D**	**d**	**Similarity index E_H**
1	Primary forest	3,88	0,98	8,34	0,99
2	Secondary forest	4,18	0,98	11,58	0,98
3	Secondary grassland	3,31	0,96	5,93	0,97
4	Shrub scrub intergrating with the g secondary timber tree	4,32	0,99	13,12	0,98
5	Bamboo forest	3,39	0,96	6,47	0,94
6	Around villages and swidden field	4,12	0,98	11,71	0,95

The Simpson 1-D index fluctuated identically low in all of the habitats, the highest valua was about 0,99 in the shrub scrub ***intergrating with the*** secondary timber tree, the lowest valua was 0,96 in the secondary grassland and the bamboo forest. The highest value of d index was in the shrub scrub intergrating with the secondary timber tree (d = 13,12), the lowest was in secondary grassland (d = 5,93). The Similarity index E_H valuas ranged from 0,94 to 0,99, the highest index was in the primary forest (E_H = 0,99), and the lowest index was in the bamboo grove (E_H = 0,94). Thus, the shrub scrub intergrating with the secondary timber tree had the highest H, 1-D, and d indices, following by the secondary forest, arounding villages and swidden field, and primary forests, respectively. The bamboo forest and the secondary grasslands were low in number of individual and species, much less diverse than in comparasing with other habitats.

The similarity of insect composition of major families is presented in Table 3.16.

Table 3.16. The similarity index of species composition of 6 major families based on habitat

Habitat	Secondary forest	Secondary grassland	Shrub scrub alternating secondary timber tree	Bamboo forest	Around villages and swidden field
Primary forest	0,77	0,40	0,70	0,16	0,55
Secondary forest	1	0,46	0,86	0,47	0,75
Secondary grassland		1	0,47	0,36	0,52
Shrub scrub alternating secondary timber tree			1	0,51	0,85
Bamboo forest				1	0,56

3.2.1.2. The species diversity of 6 major families related to the seasons and altitude

In the rainy season, the diverse indices of H', 1-D, and E_H were higher than the dry season, but the species richness index (d) in the dry season was higher in comparasion with two the others in the rainy season. The disparity between species diversity indices by altitude were not much significant, Shannon diversity index at elevation under 700m was insignificantly larger than at elevation above 700m, but Simpson 1-D index did not change by altitude. At altitude above 700 m, the d index was greater than itself at altitude under 700 m, but the E_H index valua was lower (Table 3.17).

Table 3.17. The species diversity of 6 major families in the seasons and altitude

Season/ altitude		**Diversity index**				**Similarity index (SI)**
		H'	**1-D**	**d**	**E_H**	
Season	Rainy season	4,47	0,987	12,84	0,98	0,96
	Dry season	4,28	0,983	13,09	0,96	
Altitude	>700 m	4,37	0,98	14,25	0,968	0,98
	<700 m	4,43	0,98	12,66	0,972	

3.2.1.3. The species indicator for habitat

The number of indicator species and detector species is shown in Table 3.19, the number of indicator species and detector species in the primary forest were the largest, following by the habitat arounding the village and swidden field, and the lowest was in the secondary grassland.

Table 3.19. The number of indicator species and detector species

Values	**Habitats**					
	Primary forest	Secondary forest	Secondary grassland	Shrub scrub alternating secondary timber tree	Bamboo forest	around the village and swidden field
Indicator species	17	8	3	6	9	15
Detector species	12	7	4	2	4	7

3.2.2.5. Proposing the species of beetle of conservation value in Pu Luong Nature Reserve

The study has proposed a list of beetle species, which is needed for conservation and development in Pu Luong Nature Reserve, including: 37 species belonging to 5 families, in which the Lucanidae had 7 species of 5 genera; The Passalidae had 4 species of 3 genera; Scarabaeidae had 9 species, of 8 genera; the Coccinellidae had 4 species of 3 genera, and Carabidae had 13 species of 10 genera.

3.3. Biological and ecological characteristics of subspecies *Serrognathue platymelus sika* Krieshe, 1920 and *Aceraius grandis* Burmeister, 1847

3.3.1. Characteristics of subspecies Serrognathue platymelus sika (Krieshe, 1920)

3.3.1.1. Morphological characteristics of subspecies Serrognathue platymelus sika

+ Egg stage: Eggs are white, soft, spherical, with a diameter of 2,1 – 2,4mm, average value of 2,2 ± 0,1mm.

+ Larval stage: 1st instar: body lenght is 16 - 21mm with average value of 18 ± 1,5mm and body width is 3 - 5mm with average value of 4,0 ± 0,7mm. 2nd instar: body lenght is 27 - 32mm with average value of 29 ± 0,5mm and body width is 5-7mm with average value of 6,0 ± 0,7mm. 3rd instar: body lenght is 44 - 47mm with average value of 45 ± 0.9mm and body width is 8 - 11mm with average value of 9 ± 0.9mm.

+ Pupal stage: Pupa is 29 - 34mm in length with average value of 31 ± 1,7mm and 9-12mm in width with average value of 10 ± 1,1mm.

+ Adult stage: Adult females have body length of 37 - 41mm, 39,0 ± 1.6mm in average and body width of 12-15mm, 13 ± 1,1mm in average. Adult males are larger in size with body length of 46 - 51mm, 48 ± 1,7mm in average and body width of 18 - 23mm, 20 ± 1,5mm in average.

3.3.1.2. Biological and ecological characteristics of subspecies Serrognathue platymelus sika

a) Habits of subspecies *Serrognathue platymelus sika*

- Living habits: The appropriate habitat of *S. platymelus sika* is rotten branches and woody plants which are under forest canopy, laying on the ground and having high huidity. Rotten or dead stumps and decaying woody plants are also suitable habitats.

Before each molting, the larva stops eating and stay in the prepared nest, the body shrinks, the back skin cracks in the middle, from which the larva bends many times and then gets out of the old skin. It stays till for 1-2 hours, then crawls in search of food. Young larva at the 1st instar eats a little, moves quite fast at the end of the 1st instar, at 2nd instar and 3rd instar eats a lot. At the end of the 3rd instar, larva keeps eating but moves slowly to turn into pupal stage, making nests for pupa. In the beginning of adult stage, the body is still soft, and is remained in the nest. After 4-5 days, it begins to move out of the nest and after 7-8 days, the body becomes strong and the adult begins to eat.

- Eating habits

+ Favorite foods

The analyzed results according to the Ducan standard show that, when testing with four types of food for the 2nd instar, the most favorite food of *S. platymelus sika* larvae is the rotten wood with an average rate of 65,19 % chosen by the larvae, the lowest rate is 4,07% for cow dung (table 3.21). Examining with different raising conditions showed that temperature and humidity do not affect significantly the rate of larvae choosing the foods (F = 0.031; Sig F = 0.97> 0.05).

Table 3.21. Food choices by the larvae of *Serrognathue platymelus sika*

Raising conditions	No of cpeciment	Rate of larvae choosing food types (%)				Temprature (^oC)	Humidity (%)
		Fresh wood	*Rotten wood*	*Rippen banana*	*Cow dung*		
Condition 1	30	11,11	67,78	15,56	5,56	27,5	80
Condition 2	30	13,33	65,56	16,67	4,44	29	90
Condition 3	30	14,44	62,22	21,11	2,22	30,3	82
Average	30	12,96	65,19	17,78	4,07	28,9	84

In the adult stage, the analyzed results of testing four types of food according to the Ducan standard showed that the most favorite food is the rotten wood with an average rate of 62.59% chosen by the adult. Adults of *S. platymelus sika* do not feed on cow dung (table 3.22).

Table 3.22. Food choices of the adult of *Serrognathue platymelus sika*

Raising conditions	No of cpeciment	Rate of adults choosing food types (%)				Temprature (^oC)	Humidity (%)
		Fresh wood	*Rotten wood*	*Rippen banana*	*Cow dung*		
Condition 1	30	18,89	63,33	17,78	0	27,5	80
Condition 2	30	21,11	64,44	14,44	0	29	90
Condition 3	30	23,33	60,0	16,67	0	30,3	82
Average	30	**21,11**	**62,59**	**16,30**	**0**	**28,9**	**84**

+ Eating time

The larvae of *S. platymelus sika* eat mainly during the day. They eat most in the morning, around 8 am - 11 am, and they do not eat from 23:00 pm to 2:00 am. The larvae usually molt during the day, in the morning at 8 am-11 am with the highest rate of moulting larvae by 43.7%. Within period from 2 am to 5 am, there was 4.81% of larvae moulting which was not observed in other time during the day (Table 3.23). Unlike the larvaes, the rate of adult *S. platymelus sika* feed at night is higher, they eat most during 20 pm-23 pm, after which the eating rate decreases.

Table 3.23. Rate of larvae and adult *Serrognathue platymelus sika* molting and eating at different times of the day (raising on the field)

Time periods	Rate of larvae moulting (%)	Rate of larvae and adult eating in each time period (%)	
		Larvae	*Adults*
8:00 – 11:00	43,70	45,56	12,22
11:00 – 14:00	24,81	31,85	9,26
14:00 – 17:00	10,74	23,33	7,41
17:00 – 20:00	0,0	18,89	20,00
20:00 – 23:00	0,0	8,52	48,15
23:00 – 2:00	0,0	0,0	38,89
2:00 – 5:00	4,81	6,67	17,78
5:00 – 8:00	15,93	19,63	8,52

b) Reproductive behavior of subspecies *Serrognathue platymelus sika*

The rate of mating and laying eggs of the adult *S. platymelus sika* at different times of the day is shown in Table 3.24. The mating rate reaches the highest value at 17:00 pm - 20:00 pm, then graduately decreases, and the adults do not mate at 11:00 am- 14:00 pm. The highest rate of laying egg is at period of

20:00- 23:00pm, then it graduately decline and the lowest rate of laying egg is between 11:00 am and 14:00pm during the day.

Table 3.24. Rates of mating and laying eggs of the adult *Serrognathue platymelus sika* at different times of the day

Time period	Rates of mating and laying eggs of the adult at each time period (%)	
	Rate of mating	*Rate of laying egg*
8:00 – 11:00	4,44	6,67
11:00 – 14:00	0,0	5,19
14:00 – 17:00	5,93	5,56
17:00 – 20:00	31,85	12,96
20:00 – 23:00	28,52	37,41
23:00 – 2:00	16,30	16,30
2:00 – 5:00	8,15	8,52
5:00 – 8:00	4,81	7,41

c) Duration of development stages and life cycle of *Serrognathue platymelus sika*

+ In different raising conditions, development duration is 23 ± 0.67 days in average for egg stage, 315 ± 0.5 days for larval stage, 41 days for pupal stage, and 45 days for adult stage.

+ Duration of life cycle: life cycle of *S. platymelus sika* raising in condition 1 is 398 ± 0.7 days in average, shorter than that in raising condition 2 and 3 with 31 and 50 days, respectively. Thus, different raising conditions do affect duration of life cycle (F = 19.62; Sig F = 0.002 <0.05).

Table 3.14. Duration of development stages and life cycle of *Serrognathue platymelus sika*

Development stages	Development duration in each raising conditions (days)		
	$T_{tb}=24^oC$, $RH_{tb}= 82\%$ (Condition 1)	$T_{tb}= 22^oC$, $RH_{tb}= 86\%$ (Condition 2)	$T_{tb}=18,5^oC$, $RH_{tb}= 92\%$ (Condition 3)
Eggs	20±0,7 (19-23)	24 (22-27)	26±0,33 (25-28)
1st Instar	97±0,3 (94-102)	106±0,33 (99-113)	114±0,33 (112-117)
2nd Instar	95 (92-98)	100±0,33 (97-106)	102±0,67 (97-109)
3rd Instar	106 (102-109)	110±0,67 (107-115)	114 (109-119)
Pupa	38±0,3 (36-42)	41±0,67 (39-45)	43±0,33 (42-45)
Pre-oviposition duration	41±0,3 (39-43)	46±0,33 (45-47)	47±0,83 (46-49)
Life cycle	398±0,7 (382-417)	429±0,33 (409-453)	448±0,5 (431-467)

d. Fertility of subspecies *Serrognathue platymelus sika*

- Gender index: The sex index (i) is monitored from the pupal stage to the adult stage. Statistical results about the number of male and female individuals completing metamorphosis (table 3.26) indicate that the sex index is 0.46 <0.5 in average for different raising conditions. In raising condition 2 and condition 3, the number of males is greater than that of female (i <0,5). However, in raising condition 1, the number of male is less than that of female (i > 0,5).

Table 3.26. Metamorphosis completing rate and gender index of subspecies *Serrognathue platymelus sika*

Number of monitored pupa (pupa)	Male adult		Female adult		Gender index	Raising condition	
	Quantity	*Rate (%)*	*Quantity*	*Rate (%)*		*Temprature (^oC)*	*Humidity (%)*
90	44	48,89	46	51,11	0,51	24	82
90	49	54,44	41	45,56	0,46	22	86
90	52	57,78	38	42,22	0,42	18,5	92
270	*145*	*53,70*	*125*	*46,30*	0,46	21,5	86,7

- Egg laying capacity of the adult

Table 3.27. Egg laying capacity of the female of *Serrognathue platymelus sika*

Rounds of egg laying	Egg laying capacity in each round (egg/ a female)	Number of egg laying within a day in each round (egg/ day/female)	Temperature (^{o}C)	Humidity (%)
I	17,3 (12-21)	3,2 (2-7)	27,1	90
II	15,2 (11-19)	2,7 (2-6)	29,2	80

Table 3.27 reveals that egg laying capacity in the first round is higher than that in the second round by 2.1 eggs per a female in average. The egg number produced in the whole life is 23 - 40 eggs, 32.4 eggs in average. The number of eggs within a day 1 of the first round is greater than that of the 2nd round by 0.5 eggs / a day / a female. Interval between two rounds of egg laying is 3-5 days.

- Lifespan of an adult

Lifespan of an adult is 50 - 64 days, 57 ± 0.8 days in average in raising condition 1; 57 - 67 days, 63 ± 0.2 days in average in raising condtion 2, and 59 - 71 days, 65 days in average in raising condition 3. Thus, the external conditions do affect the life span of adults (Sig of F = 0.0001 <0.05).

The completion rate of different develoment stages: The results of determining the completion rate of different develoment stages of subspecies *S. platymelus sika* in 3 raising conditions are shown in Table 3.28.

Table 3.28. The completion rate of different develoment stages of subspecies *Serrognathue platymelus sika*

Monitored criteria	Raising conditions					
	Condition 1		***Condition 2***		***Condition 3***	
	Quantity	*Rate (%)*	*Quantity*	*Rate (%)*	*Quantity*	*Rate (%)*
Egg	110	100	115	100	110	100
1st Instar and rate of hatching egg	87	79,1	93	80,9	96	87,3
2nd Instar and completion rate of the 1st instar	78	89,7	84	90,3	87	90,6
3rd Instar and completion rate of the 2nd instar	69	88,5	77	91,7	82	94,2
Pupa and completion rate of the 3rd instar	64	92,8	68	88,3	73	89,0
Adult and completion rate of development from egg to adult	58	52,7	63	54,8	65	59,1

In raising condition 1, the hatching egg rate is 79,1%, completion rate of the 1st instar is 89,7%, completion rate of the 2nd instar is 88,5%, completion rate of the 3rd instar is 92,8% and completion rate of development from egg to adult is 52,7%. The corresponding rates are 80,9%; 90,3%; 91,7%; 88,3% and 54,8% in raising condition 2 and 87,3%; 90,6%; 94,2%; 89,0% and 59,1% in raising condition 3, respectively.

3.3.2. Characteristics of subspecies Aceraius grandis Burmeister, 1847

3.3.2.1. Morphological characteristics of subspecies Aceraius grandis

+ Egg stage: Eggs are spherical, with a diameter of 2,1 – 2,4mm, average value of 2,2 ± 0,1mm.

+ Larval stage: 1st instar: body lenght is 15 - 19mm with average value of 17 ± 1,1mm and body width is 2,5 - 4mm with average value of 3 ± 0.4mm. 2nd instar: body lenght is 25 - 29mm with average value of 27,0 ± 1,2mm and body width is 4 - 7mm with average value of 5 ± 0,9mm. 3rd instar: body lenght is 39-44mm with average value of 41 ± 2,1mm and body width is 6 - 9mm with average value of 7 ± 1,1mm.

+ Pupal stage: Pupa is 25 - 28 mm in length with average value of 26 ± 0,9 mm and 7 - 9mm in width with average value of 7,9 ± 0,7mm.

+ Adult stage: Adult females have body length of 48- 52mm, 50 ± 1.5mm in average and body width of 14-16mm, 15 ± 0.8mm in average. Adult males are smaller in size than female ones with body length of 38 -41mm, 39 ± 1.0mm in average and body width of 11-14mm, 12 ± 1.1mm in average.

3.3.2.2. Biological and ecological characteristics of subspecies Aceraius grandis

a) Habits of subspecies *Aceraius grandis*

- Living habits

A. grandis species live mainly in rotten branches and woody plants which are under forest canopy, laying on the ground and having high huidity. Rotten or dead stumps and decaying woody plants are also suitable habitats. Adult of *A. grandis* live quite long. During the day, especially on hot days, they often lurks inside plant trunks, stumps or under the ground where humidity is quite high. In the beginning of adult stage, the body is still soft, then becomes sturdy after 5-8 days, but they do not move out of the nest much. Since the life span of adult is long, the great amount of food is required. The adults dig holes, making nests in tree trunks, rotten stumps, lay trees or under the ground. Young larvaes rarely appear on the ground but are mainly active inside the plant trunks, rotten stumps, and broken lay trees, where they gnaw and chisel into. When egg hatching and becoming the 1st instar, they eat a little, then gradually eat more, and move quite quickly. When turning to the 2nd and 3rd instar, they eat a lot. Before pupation, the 3rd instars move slowly, making the pupal chamber in rotten trunks . The larvae curl their body up many times in the pupal chamber before staying till and doing pupation. As a result of larvae movement, inner surface of the pupal chamber is quite smooth and plain.

- Eating habits

+ Favorite foods

Four common food types are examined namely fresh wood and rotten wood of Gioi Lang (*Michelia foveolata*), ripe bananas and cow dung using larvae at the 2nd instar. The analyzed results according to the Ducan standard show that the most favorite food of A. grandis is the rotten wood with an selection rate of 67,78%, followed by bananas with 15, 93%, fresh wood with 14,07% and only 2,22% for cow dung (Table 3.29).

Table 3.29. Food choices by the larvae of *Aceraius grandis*

Raising conditions	**No of cpeciment**	**Rate of larvae choosing food types (%)**				**Temprature (^oC)**	**Humidity (%)**
		Fresh wood	*Rotten wood*	*Rippen banana*	*Cow dung*		
Condition 1	30	14,44	70,00	13,33	2,22	27,5	80
Condition 2	30	12,22	68,89	15,56	3,33	29	90
Condition 3	30	15,56	64,44	18,89	1,11	30,3	82
Average	30	***14,07***	***67,78***	***15,93***	***2,22***	**28,9**	**84**

The analyzed results show that temperature and humidity in different raising conditions have minor effect on rate of choosing feed by *A. grandis larvae* (F = 0.0001; Sig F = 1.00> 0.05).

In adult stage, the analyzed results testing 4 types of food following Ducan standard show that the preferred food was the rotten wood with an average selection rate of 61,48%. The rate of choosing bananas by adults is relatively high by 20,74%, followed by fresh wood 17,78% and cow manure is not chosen as food (Table 3.30). The statistical analysis reveals that the rate of adults selecting foods is significantly different (F = 820,75; Sig F = 0,0001 <0,05).

Table 3. 30. Food choices by the adult of *Aceraius grandis larvae*

Raising conditions	**No of cpeciment**	**Rate of adults choosing food types (%)**				**Temprature (^oC)**	**Humidity (%)**
		Fresh wood	*Rotten wood*	*Rippen banana*	*Cow dung*		
Condition 1	30	16,67	64,44	18,89	0	27,5	80
Condition 2	30	16,67	62,22	21,11	0	29	90
Condition 3	30	20,00	57,78	22,22	0	30,3	82
Average	30	***17,78***	***61,48***	***20,74***	**0**	**28,9**	**84**

+ Eating time

The results of monitoring the eating time show that larvae of of *A. grandis* has a habit of eating a lot in the daytime. They eat most in the morning at 8-11 am and eat less around 11 am-14 pm. Larvae eat greatly in the afternoon at 14-17 pm. In the evening, the number of larvae eating is very low, especially at 23 pm- 2 am. After 2 am, rate of larvae eating increases from 6,67% at 2-5 am to 18,15% at 5-8 am (Table 3.31).

Larvae usually moult during the daytime, the highest rate of moulting is observed at 8-11 am in the morning . The rate of larvae moulting is 24,81% in period of 11 am-14 pm and 10,37% in period of 14-17 pm. Moulting rate decreases and stops at 20 pm-2 am. After this time, they begin to moult again.

Table 3.31. Rate of larvae and adult *Aceraius grandis* molting and eating at different times of the day

Time periods	**Rate of larvae moulting (%)**	**Rate of larvae and adult eating in each time period (%)**	
		Larvae	*Adults*
8:00 – 11:00	44,44	51,11	17,41
11:00 – 14:00	24,81	25,19	12,59
14:00 – 17:00	10,37	21,48	13,33
17:00 – 20:00	2,22	11,48	27,04
20:00 – 23:00	0,0	5,93	38,89
23:00 – 2:00	0,0	1,85	18,89
2:00 – 5:00	5,56	6,67	12,96
5:00 – 8:00	12,59	18,15	15,56

Adult of *A. grandis* eat greatly in the evening with eating rate of 27,04% at 17:00 - 20:00 pm, and reaching the highest rate of 38,89% at 20 - 23 pm. The rate of adults eating is 18,89% of the total number of monitored adults around 23 pm-2 am, and then decreases. In other times, adults still eat, but eating rate is very low. In addition, the eating time of *A. grandis* is affected by climate and weather conditions, biological relationship with other species, and food sources. The food source also affects the lifespan of adult stage, reproductive process and characteristics of *A. grandis*.

b) Reproductive behavior of species *Aceraius grandis*

After 15-20 days of emergence, *A. grandis* start mating with the male-above mating position. The male use front legs to hold the female's chest, middle and hind legs to hug the the female's belly, then the male inserts the mating spine into the female genitals. They often mate in the dark and discreet places. During the day, they mate mainly in the evening with the highest rate of adults mating of 35,19% at 17-20 pm and the lowest mating rate at 11-14 pm with 0,37% of adult mating. Mating duration is longer and mating process is more convenient when the female has adequate and suitable food sources and has no adverse effects of the external environment.

Adults of *A. grandis* lay egg mainly in the early morning from 5-8 am with 13,33% of adults laying eggs. The rate of laying egg reaches the peak of 38,15% at 8-11 am, then gradually decreases in the evening at 20 – 23 pm with the lowest egg laying rate of 3,33%. At 23pm - 2 am, adults do not lay eggs, but lay eggs again at 2-5 am by 7,04% (Table 3.32).

A. grandis lays eggs in discreet places such as in a hole or in natural crevices of the trunk with high humidity. Before laying eggs, adult females spend 3-4 days for digging around, chewing wood into debris and compressing debris to prepare place for laying eggs. Eggs are laid on debris from chewed wood. Because of long egg laying duration, the hatching time varies, resulting in different size and age of the larvae.

Table 3. 32. Rates of mating and laying eggs of the adult *Aceraius grandis*

Time period	**Rates of mating and laying eggs of the adult at each time period (%)**	
	Rate of mating	*Rate of laying egg*
8:00 – 11:00	2,96	38,15
11:00 – 14:00	0,37	16,67
14:00 – 17:00	6,67	13,33
17:00 – 20:00	35,19	8,15
20:00 – 23:00	26,30	3,33
23:00 – 2:00	12,96	0,00
2:00 – 5:00	8,15	7,04
5:00 – 8:00	7,41	13,33

Before laying eggs, the female moves slowly and then stays still to lay eggs. Eggs are laid individually or in clusters of 7-11 eggs which are sticked to the substrate or sticked together by adhesives secreted by the gonads. Before hatching, the egg shell cracks a horizontal line from which the larvae got outside. The hatching is mainly occurred in the morning at 8-11 am, after this time the eggs still hatch until the evening but the hatching rate is low.

c) Duration of development stages and life cycle of *Aceraius grandis*

+ Duration of egg stage: In raising condition 3, duration of egg stage is 18 ± 0,8 days, which is not significantly longer than that in conditions 1 and 2 with 1 ± 0,6 days and 1 ± 0,3 days, respectively. In average, duration of egg stage in different raising conditions is 18 ± 0,2 days (Table 3.33).

+ Duration of larval stage: Duration of larval stage is 61 – 69,5 days, 65 ± 0,5 days in average, for raising condition 3; 55,5 – 65,5 days, 61 ± 0,4 days in average, for raising condition 2, and 55.5 - 65 days, 59 ± 0,2 days in average, for raising condition 1. Generally, duration of larval stage in different raising condtions is 61 ± 0,2 days.

+ Pupal stage: Analyzed results indicate that temperature and humidity have minor significant affect on duration of pupal stage (F = 0,330; Sig F = 0,746> 0,05). Duration of pupal stage is 14-18 days. During this time, pupa remain inside the trunk and are not affected by external conditions. In average, pupal stage in different raising conditions lasts for 16 ± 0,3 days.

+ Pre-oviposition duration of the adult: Temperature and humidity have no significant affect on pre-oviposition duration of the adult (F = 2,27; Sig F = 0,14). > 0,05). Pre-oviposition duration in all raising conditions is 26 ± 0,3 days in average.

Table 3.33. Duration of development stages and life cycle of *Aceraius grandis*

Development stages	Development duration in each raising conditions (days)		
	T_{tb}=24^{o}C, RH_{tb}= 82% (Condition 1)	*T_{tb}= 22^{o}C, RH_{tb}= 86%* (Condition 2)	*T_{tb}=18,5^{o}C, RH_{tb}= 92%* (Condition 3)
Egg	17±0,2 (16-18,5)	17±0,5 (15,5-19)	18±0,8 (17,5-20)
1st Instar	18 (16,5-20,5)	17±0,2 (15-19,5)	20±0,3 (18,5-22,5)
2nd Instar	15±0,5 (14,5-17)	16±0,3 (15-17)	17±0,3 (16-18)
3rd Instar	25±0,7 (24,5-27,5)	27±0,5 (25,5-29)	27±0,8 (26,5-29)
Pupa	15±0,5 (14-17,5)	16±0,5 (14,5-18)	15±0,8 (15-17)
Pre-oviposition duration	24±0,8 (23-27)	27±0,7 (25,5-29,5)	27±0,8 (26-29,5)
Life cycle	116±0,7 (108,5-128)	122±0,7 (111-132)	128 (119,5-136)

+ Life cycle duration: The results from Table 3.33 show that life cycle of *A. grandis* is 122 days in average. Different raising conditions clearly affect life cycle duration of *A. grandis* (F = 8,227; Sig F = 0,019 <0,05). Higher temperatures and lower humidity result in shorter life cycle. Life cycle of *A. grandis* in raising condition 1 is shorter than that in raising condition 2 and 3 by 6 ± 0,1 days and 12 ± 0,3 days, respectively.

d) Fertility of species *A. grandis*

- Gender index

Under different raising condition, the number of males is greater than that of females, with everage gender index i = 0,46 <0,5 for 3 raising condition. Of which, gender index is highest in raising condition 2 and lowest in condition 1 (Table 3.34).

Table 3.34. Metamorphosis completing rate and gender index of species *Aceraius grandis*

Number of monitored pupa (pupa)	Male adult		Female adult		Gender index	Raising condition	
	Quantity	*Rate (%)*	*Quantity*	*Rate (%)*		*Temprature (^{o}C)*	*Humidity (%)*
90	51	56,67	39	43,33	0,43	24	82
90	47	52,22	43	47,78	0,48	22	86
90	48	53,33	42	46,67	0,47	18,5	92
270	*146*	*54,07*	*124*	*45,93*	0,46	28,9	84

- Egg laying capacity of the female of *A. grandis*

Egg laying capacity in the 1st round is 8-15 eggs/ a female, 12,03 eggs /a female in average. In the 2nd and 3rd rounds, a female lays 9 - 14 eggs, 10,1 eggs/ a female in average and 7 - 12 eggs, 8,2 eggs/ a female in average, respectively. Egg laying capacity of a female in the lifetime is 24-36 eggs with average value of 30,9 eggs / a female. Hence, egg laying capacity in the 1st round was greater than that in the 2nd and 3rd rounds by 1,33 eggs /a female and 3,86 eggs / a female, respectively (table 3.35).

Table 3.35. Egg laying capacity of the female of *Aceraius grandis*

Rounds of egg laying	Egg laying capacity in each round (egg/ a female)	Number of egg laying within a day in each round (egg/ a day/ a female)	Temperature (^oC)	Humidity (%)
I	12,03 (8-15)	2,29 (1,29-3)	24	82
II	10,7 (9-14)	1,9 (1,5-2,75)	22	86
III	8,17 (7-12)	1,73 (1,4-2,4)	18,5	92

- *Lifespan of an adult:* Lifespan of an adult in raising condition 1 is 227 - 273 days, 248 ± 0.3 days in average. That in raising condition 2and 3 is 235.5 - 277.5 days, 259 ± 0.4 days in average, and 246 - 287.5 days, 266 ± 0.7 days in average, respectively. Thus, the external conditions affect the lifespan of the adult, raising condition 1 having higher temperature and lower humidity results in shorter lifespan as compared to raising conditions 2 and 3 by 11.1 days and 18.4 days, respectively.

- *The completion rate of different develoment stages*: In raising condition 1, hatching egg rate is 65.8%, completion rate of the 1st instar is 91,1%, completion rate of the 2nd instar is 90,3%, completion rate of the 3rd instar is 92,3%, and completion rate of development from egg to adult is 45,8%. The corresponding rates are 66,7%; 92,5%; 91,9%; 91,2% and 47,5% in raising condition 2 and 65,6%; 93,9%; 92,2%; 91,5% and 48,8% in raising condition 3, respectively. External conditions have no significant affect on the completion rate of different develoment stages of A. grandis. Completion rates of development from egg to adult are 45,8%, 47,5% and 48,8% in raising conditions 1, 2 and 3, respectively, indicating no significant difference (Table 3.36).

Table 3.36. The completion rate of different develoment stages of species Aceraius grandis

Monitored criteria	Raising conditions					
	Condition 1		Condition 2		Condition 3	
	Quantity	Rate (%)	Quantity	Rate (%)	Quantity	Rate (%)
Egg	120	100	120	100	125	100
1^{st} Instar and rate of hatching egg	79	65,8	80	66,7	82	65,6
2^{nd} Instar and completion rate of the 1^{st} instar	72	91,1	74	92,5	77	93,9
3^{rd} Instar and completion rate of the 2^{nd} instar	65	90,3	68	91,9	71	92,2
Pupa and completion rate of the 3^{rd} instar	60	92,3	62	91,2	65	91,5
Adult and completion rate of development from egg to adult	55	45,8	57	47,5	61	48,8

The hatching rate of species *A. grandis* ranges from 65,6% to 66,7%, lower than that of subspecies *S. platymelus sika* with hatching rate ranging from 79,1% to 87,3%. This is the reason for the low completion rate of development from egg to adult of *A. grandis*, ranging from 45.8% to 48.8%, while that of *Serrognathue platymelus sika* is from 52,7% to 59,1%.

The above results of this study indicate that average duration of life cycle of *A. grandis* in 3 raising conditions is 122 days, whereas that of subspecies *S. platymelus sika* is much longer, 398 days. Average lifespan of *A. grandis* in raisisng conditions is 248 - 266 days while that of subspecies *S. platymelus sika* is shorter by 57 - 64 days. The main cause is due to the longer larval stage of subspecies *S. platymelus sika*, 315 days in average, as compared to that of *A. grandis*, 61 days in average.

3.4. The current status and recommendations for the conservation and development of beetle in Pu Luong Nature Reserve

3.4.1. The current status of management of special-use forests in Pu Luong Nature Reserve

- *Strictly protected sub-zone:* beetle species mainly belonged to the Lucanidae, Passalidae, and the Scarabaeidae. The management was the application of strict protection measures for the whole forested area, and forest land., Besides, it was possible to investigate and study flora and fauna in general and beetle in particular.

- Ecological rehabilitation sub-zone: beetle species belonged to the Lucanidae, Passalidae, Scarabaeidae, Carabidae, and the Coccinellidae family. In this subzone, it was necessary to protect the existing forest area, to prohibit the cutting of forest trees, to hunt forest animals, to restorate and-oriente forest protection areas, and to enrich the forest by supplementing additional indigenous tree species in combination with the serving eco-tourism.

- Service and administrative subdivisions: This area were large enough to arrange the construction of conferences, scientific research facilities, centers for wildlife conservation and development, museums, library, botanical garden, visitor center.

3.4.2. The factors affect to the conservation and development of beetle

The generation and development of beetle depend on three factor groups: (1) The intrinsic factor group of the forest ecosystem (plant species composition, age structure, stratum structure, litter layer, process growth, development, forest regeneration, and succession in forest sere); (2) Group of geographic factors, slope, and climate conditions; (3) Group of factors outside the ecosystem that have indirectly effect to the beetle fauna through impactions on forest plants (also known as human factors group: policies of forest management, exploitation and use, biodiversity conservation, social and economic conditions...). These are the main factors affecting beetle conservation and development, in which the group of factors (1) and (2) are objective, simultaneously, this is a special-use forest. The further impact measures are mainly implemented in the buffer zone. Therefore, the application of measures to factor of groups (1) and (2) is limited.

The plant composition and forest ecosystem structure defined the composition, diversity and abundance of the beetle fauna, so that the causes of influence on forest plant were also harmful for beetle fauna. The area of the strictly protected sub-area was about 12,561.6 ha, it was the place, where had high diversity in terms of forest types, stratum structure so that the diversity and abundance of the beetle fauna were quite high, especially, the dense forest litter layer helped for the species of Scarabaeidae, Carabidae, and Lucanidae become s dominated.. In the ecological rehabilitation sub-zone, forest plants had been exploited, and due to the forest area in this subdivision had a high slope, complex topography, a wide range of climate conditionss, so the diversity of the beetle was low.

People are considered as the main impacted factor to the beetle by their indirect activitise-on forest plants. The direct factors such as capturing for sale or for, which have little impact to the beetle.t. Therefore, in order to conserve and develop the beetles, it is necessary to implement the measured solutions to monitor the habitat and the human activities.

3.4.3. Proposing the measured solutions for preservation and development of the beetles

3.4.3.1. Building the biodiversity Monitoring Programs

* Species monitoring

- Monitoring objects: Monitoring objects werethe species of conservation value: including: 37 species belong to 5 families, in which, there were 7, 4, 9, 4, and 13 species 9belonged to the Lucanidae, Passalidae,Scarabaeidae, Coccinellidae, Carabidae family, respectively.

- Contents: Monitoring the number and the size of populations of beetle species.

- Monitoring indicators:

+ Monitoring species of the composition, density, frequency of occurrence, and distributed range of beetle species;

+ The main food plant species for the beetle species;

+ The natural enemies, the other serious threats, and the changes of threats to the species;

+ The changes in a long-term trend of population size.

- Solution measures

+ Investigation of the beetle at the selected sites or routes.

+ Investigation, captrue of the beetle by using net, light traps, pitfall traps, combine capture directly at the root, trunk, and underground.

* Habitat monitoring and human impacts

- The objects selected for monitering was habitats, including: The primary forest, the secondary forest, the secondary grassland, the arounding village and swidden field, and the shrub scrub intergrating with the secondary timber tree.

- The contents of monitoring: Monitoring the level of impact on the habitats and the forms of human activities.

- The monitoring indicators: The indicated species for each habitat type, number of people, the forms and the extent of impacts on the habitat, the affected habitat area, the number of individuals found to be captured.

- Supervision measures

+ Determination of the indicator value of the beetle species

+ Monitoring and assessment of the current status of forest area and the management.

+ Identification of the key factors, which affect to the conservation and the conservation of the beetle.

3.4.3.2. Silvicultural measures

The basis of the silvicultural measures is to create a suitable living environment, a place for residence, and a diverse food source for the beetle species. The silvicultural measures applied to each habitat are summarized in the following table.

Table 3. 39. Proposal of silvicultural technical measures in various habitat for conservation and development of beetles

Habitats	Easily affected beetles	Silvicultural technical measures
1. Primary forest	The species of the Lucanidae, Passalidae, Scarabaeidae, Carabidae family, and the *Micraspis discolor* of Coccinellidae family.	- Forest protection - Zoned for natural regeneration and promotion
2. Secondary forest	*The Dorcus affinis, Prismognathus angularis, Prosopocoilus buddha, P. inquinatus nigritus,and the Serrognathue platymelus sika* of Lucanidae family. *Aceraius grandis, Ceracupes arrowi, Leptaulax dentatus* of the Passalidae family, and the family of Scarabaeidae and Carabidae.	- Forest protection - Zoned for natural regeneration and promotion; Zoned for natural regeneration promotion with supplementary planting - Forest nurturing - Forest enrichment by belts and segment
3. Secondary grassland	*The Onitis virens* and the *Onthophagus kindermanni* of the Scarabaeidae faminly. *Micraspis hirashimai* belong to Coccinellidae. *Chlaenius bimaculatus, C.*	- Forest enrichment by strip and segment - Afforestation

Habitats	Easily affected beetles	Silvicultural technical measures
	circumdatus, Cosmodela virgula and *Pseudognathaphanus punctilabris* belong to Carabidae	
4. Shrub scrub intergrating with the secondary timber tree	*The Dorcus affinis, Prismognathus angularis, Prosopocoilus buddha, and the Serrognathue platymelus sika* of the Lucanidae family. *Ceracupes arrowi, Leptaulax dentatus* of the Passalidae family. The species of the Scarabaeidae family exception the *Chalcosoma atlas. Menochilus sexmaculatus, Micraspis discolor* and *Synonycha grandis* of the Coccinellidae family and thespecies of the Carabidaefamily .	- Forest protection - Zoned for natural regeneration promotion with supplementary planting - Forest nurturing - Forest enrichment by strip and segment - Afforestation.
5. Bamboo forest	*The Paragymnopleurus melanarius* of the Scarabaeidae family. The *Micraspis hirashimai* belong of *the* Coccinellidae family. the *Cosmodela virgula* and *Scarites terricola* of the Carabidae family.	- Forest nurturing - Forest enrichment by strip and segment
6. Arounding the village and swidden field	The species of the Scarabaeidae family. The *Menochilus sexmaculatus, Micraspis discolor,* and *Synonycha grandis* of the Coccinellidae family. The *Chlaenius bimaculatus, C. circumdatus, C. praefectus, C. sericimicans, Colfax stevensi, Cosmodela virgula, Trigonotoma chalceola* of the Carabidae family.	- Afforestation - Building of household gardens

The contents of silvicultural measures as follows:

+ Protection measures: This measure should be implemented in the habitats such as the primary forests, the secondary forests, the shrub scrubs intergrating with the secondary timber trees in order to protect the habitats of spcies of the Lucanidae, Passalidae, Scarabaeidae, and the Carabidae families and the species of *Menochilus sexmaculatus, Micraspis discolor,* and the *Synonycha grandis* of Coccinellidae family. Therigorous protection of the entire forested area and the forest land, identification of the important locations for the controlation and prevention from the negative impacts on forest resources.

+ Zoned for the natural regeneration promotion: Applying this measure in the primary forests and the secondary forests in order to protect and create favorable habitats for the species of the Lucanidae, Passalidae, Scarabaeidae, Carabidae families, and the Micraspis discolor species of the Coccinellidae family. the applied measures are the protection and prohibition of the cutting down the existing regenerated trees, the preventationg and fighting forest fires, clearance the shrubs and cutting the crooked trees, cutting down tree which are infected with pests and diseases, clearance of the purposeless tree, pruning; thinning and forest sanitation.

+ Zoned for natural regeneration promotion with the supplemented plantation: the measures is needed to apply in the secondary forests, the shrub scrubs intergrationg with the secondary timber trees in ecological restoration sub-zone of Pu Luong Nature Reserve in order to protect and create suitable environment for species of the Lucanidae, Passalidae, Scarabaeidae, Carabidae families, and the species *Menochilus sexmaculatus, Micraspis discolor,* and *Synonycha grandis* of the Coccinellidae family.

The miSmplementation measures: Protection and fight against the deforestation of existing regenerated trees, preventation and fight forest fires, Clearing vines, shrubs and cutting shriveled plants, pests, non-purpose trees,repairing shoots, and pruning bad shoots,

- *Forest nurturing and Forest enrichment:* This solution is applied in the habitat of secondary forests, shrub scrubs intergrating with the secondary timber trees, the bamboo forests in the sub-zone ecological restoration and the forest enrichment approach is also used in the secondary grasslands for conservation and development of the *Dorcus affinis, Prismognathus angularis, Prosopocoilus buddha, P. inquinatus nigritus, Serrognathue platymelus sika* of the Lucanidae family, andthe species *Aceraius grandis, Ceracupes arrowi, Leptaulax dentatus* belonging to Passalidae family. The species belongs to the family of Scarabaeidae, Carabidae, and Coccinellidae, respectively

- Afforestation and building of household gardens

Selection the tree species: selection of the native trees, which distributed in Pu Luong Nature Reserve such as the *Madhuca pasquieri, Chukrasia tabularis, Erythrophleum fordii , Podocarpus, Indosasa amabilis, and the Melia azedarach Dendrocalamus barbatus*. Procession of vegetation treatment, afterward mixing plantation at least two or more tree species by strip or segment.

3.4.3.3. The solution of raising some groups of beetles

In the study area, it can be raised some groups of beetle species: The group belongs to the superfamily of Scarabaoidea (including families of Scarabaeidae, Lucanidae, Passalidae), the group belongs to the Carabidae, and the group belongs to the Coccinellidae, in which, some specific species have the conservation value, which should be selected for raising.

For species of the superfamily of Scarabaoidea can be raised in semi-artificial mothod in order to increase the number of individuals or the species of conservation value.

The raising techniques: Choosing a places, where the shrubs, rotten trees are available for breeding cages with an area from 20 to25m^2, and with height from 2 to 3m , around and above is covered by using 150-hole/cm^2 grid. Collection of the beetle species in the larvae, pupae or adult phases. At the same time, providing the rotten, the hollow trunks collected from the forest for food, shelter, rest and movement of the beetles in the raising area.

- For the Carabidae and the Coccinellidae families, it can be raised by appling the semi-artificial mothod combining with raising in the laboratories to determine more detail of their biological and ecological characteristics. In the laboratory, the individuals of the Carabidae and Coccinellidae families can be kept in plastic bottles, moistened with the cotton wool at the bottom of the bottle, mouth of the bottles is covered with a cloth or small perforations for ventilation. The food for the Carabidae and Coccinellidae is the larvae at the first age and second age of some species of the Lepidoptera order.

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

1) The results of the investigation have identified that there were 171 beetle species.Together with the 2013 survey results in the Pu Luong Nature Reserve untill the present, 193 beetle species have been identified ,which belongto 146 genera, 28 families . In which, 144 new species were added to the beetle fauna in Pu Luong Nature Reserve, and 6 major families were identified, including: the Scarabaeidae, Lucanidae, Carabidae, Cerambycidae, Coccinellidae, and the Curculionidae with a total of 122 species belonging to 88 genera.

2) For 6 investigated habitats in this study, the beetle was most distributed in the shrub scrub with the secondary timber tree, and decreased in the order of arounding the villages and swidden field, secondary forests, primary forests, bamboo forests, and the lowest occurance was in the secondary grassland. The

diversity indices were highest in the the shrub scrub intergrating with the secondary timber tree, and were lowest in the bamboo forest. The largest seasonal variation was the Scarabaeidae family. The rainy season had 6 species more than the dry season, the changes of the Carabidae and the Lucanidae was negligible, and there were no differences by season in the rest families . The disparity of the species number by elevations is insignificant: the number of species of the Scarabaeidae and Coccinellidae were distributed at elevation below 700m higher than above 700m, 3 and 1 species, respectively, while there is no disparity in other families by elevation. The thesis has proposed a list of 37 species of 5 families, which were prioritized for conservation and development in Pu Luong Nature Reserve, including: 7 species of the Lucanidae, 4 species of the Passalidae, 9 species of the Scarabaeidae, 4 species of the Coccinellidae, and 13 species of the Carabidae, respectively.

3) The subspecies *Serrognathue platymelus sika*: Egg stage: with an average diameter value of 2,2 ± 0,1mm. Larvae has 3 stages with body length of 1st instar, 2nd instar and 3rd instar of 18±1.5mm, 29±0,5mm và 45±0,9mm, respectively. Pupa is 29 - 34mm in length with average value of 31 ± 1,7mm. Adult stage: Adult females have average length 39,0 ± 1.6mm and average width 13 ± 1,1mm. Adult males are larger in size with average length 48 ± 1,7mm and average width 20 ± 1,5mm. In raising condition at temperature of 18,5 – 24^{o}C and humidity of 82-92%, the egg number produced in the whole life is 23 - 40 eggs and the sex index is 0.46. Development duration is 23 ± 0.67 days in average for egg stage, 315 ± 0.5 days for larval stage, 41 days for pupal stage, 45 days for adult stage and average life cycle is 425 days. The species *Aceraius grandis*: 1st instar: body lenght is 17 ± 1,1mm and body width is 3 ± 0.4mm. 3rd instar: body lenght is 41 ± 2,1mm and body width is 7 ± 1,1mm. Pupa is 26 ± 0,9 mm in length, adult females have body length of 50 ± 1.5mm in average and body width of 15 ± 0.8mm in average and adult males have body length of 39 ± 1.0mm in average and body width of 12 ± 1.1mm in average. In raising condition at temperature of 18,5 – 24^{o}C and humidity of 82-92%, the egg number produced in the whole life is 24-36 eggs and the sex index is 0.46. Development duration is 18 days in average for egg stage, 61 days for larval stage, 16 days for pupal stage, 27 days for adult stage and average life cycle is 122 days.

4) In order to effectively conserve and develop the beetles in Pu Luong Nature Reserve, Biodiversity Monitoring Program should be concerned to monitor the valuable beetles, the habitats, and human activities. The silvicultural measures such as the habitat protection, setting bounds to and fostering natural regeneration, Setting bounds to and fostering natural regeneration with the supplementary plantation, forest nurturing, forest enrichment, afforestation, and building of household gardens should be taken into account. The raising in semi-artificial mothod combining with the laboratory breeding for some valuable conservation of beetles of the Scarabaeidae, Lucanidae, Passalidae, Carabidae, and the Coccinellidae families.

2. Recommendations

- The thesis results are specific guidelines that can be used for the planof the beetle conservation in Pu Luong Nature Reserve.

- Continue researching and raising beetle to determine the biological and ecological characteristics of valuablconservation e of beetles in the list of 37 species of 5 families in both of the semi-natural conditions, and in the laboratory.

- Further research, and appling the silvicultural techniques, especially methods of nurturing and enriching forests in the secondary forests, secondary grasslands, shrub scrub intergrating with the secondary timber tree, and the bamboo forests to create suitable habitat for the beetles.