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Major Insect Pests and Diseases in Common Bean (*Phaseolus vulgaris* L.) Production in Ethiopia

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Abstract: Common bean (*Phaseolus vulgaris* L.) production in Ethiopia is injured by several insect pest and diseases. The major insect pests which attack common bean in pre and post harvests are the bean maggot (*Ophiomyia phaseoli*), bruchids, *Z. subfasciatus*, *C. maculates*, ootheca (*Ootheca bennigseni*) and aphids (*Aphis fabae*). These pests affected yield and yield components of common bean through direct and indirect of the total production. Some insects like Aphid is used as the way of transmitting other diseases like mosaic virus from plant to plants, in addition to direct reducing common bean production. The second constraints of common bean production under biotic is diseases virulence of fungus, bacteria and viruses. The important diseases are angular leaf spot, anthracnose, rust, bacterial blight, and mosaic, halo blight and ascochyta blight causes significant yield losses. Completely free of pests production is very difficult in the world of agriculture, while reducing effects as level of under economic importances. Minimizing the losses caused from insect pests and diseases possible through several managements such as; cultural, biological, botanical, and chemical, and integration control methods developed. Further, to assure ecofriendly management techniques; integrated management, botanic and biological control are prioritized than chemical control methods. The main targets of current and future protection plan should be more balances to the natural system balancing than yield improvements. Thus, more encourages to control though ingratiation and economic friendly ways. Therefore, this review was revised the major common bean insect pests and diseases in the pre and post harvest, their hosts, biological and recommended management system were portrayed.

Keywords: Common Bean, Diseases, Insect Pest, Management Methods

1. Introduction

Common bean (*Phaseolus vulgaris* L.) is multipurpose leguminous crop and since it is high in nutrient content (Mwanauta *et al.,* 2015). It is second important in terms of production and area of productivity due to early maturity intercrop with other crop like maize, improver soil fertility, animal fead and become to commercial potential (Demelash, 2018). More, it has substantial role in to provide balance diet, and provides amino acid like folic acid [30]. Similar study reported as it contributed around 57% dietary protein and 23% of carbohydrate. Furthermore, Montoya [50] reported as usual a use of leguminous crops advertised due to minimizes the risk of disease such as cancer, diabetes, or coronary heart diseases.

Common bean produces more around central, northern, and western parts of the country were good soil moister available [72]. In Ethiopia, more than half of annual production from the Rift Valley areas at the central parts [8]. It is the second most important legume crop in terms of area planted and volume of production (second only to faba bean, *Vicia faba*); production in 2020/21 was around 0.55 million tons from 0.31 million hectares [25] However, the average yield of common bean in Ethiopia (1.8 tons per hectare) is far below the genetic potential of the crop, which is estimated to be ≥3 t ha^{-1} [27]. When compared with yield potential of Common bean varieties developed in Ethiopia, there is a great difference between average actual yield and yield obtained on the station. Even if the estimated and registered product of common bean was increased, not as a result of production increased per production area, rather than because of increasing land of production. This is revealed as there are constrained of increasing the production. This may occurred due to abiotic and biotic constraints.

The main reasons for low productivity of common bean in Ethiopia include luck of certified seed, disease, insect pest and weeds [8, 38]. Among the constraints, the embezzlements causes direct or indirect at pre and post harvest yield reduction by insect pest leading as first problem. From several insect pests causes yield reduction, the majors are; stem maggot (*Ophiomyia phaseoli*), ootheca (*Ootheca bennigseni*), bruchids or Weevil *(Acanthoscelides obtectus and Zabrotes subfasciatus*) and aphids (*Aphis fabae*) which causes the 37% to 100% yield loss [44]. The scope of insect pest species may cause yield reduction higher than another crops due to the crop adapted at wider agro ecology.

As similar to insect pests, considerable disease pathogens affects directly and indirectly at pre and post harvest stages. The Major diseases causes yield reduction in common bean are; Angular leaf spot (*Phaeoisariopsis griseola*), Anthracnose (*Colletotrichum lindemuthianum*), Rust (*Uromyces appendiculatus*), common bacterial blight (*Xanthomonas campestris* pv. *phaseoli*), and bean common mosaic caused by a virus, Halo blight (*Pseudomonas syringae* pv. *phaseolicola),* Ascochyta blight (*Phoma exigua* var. *diversispora* and/or *Ascochyta phaseolorum*) [31, 5]. The common characteristics of those pathogens are outbreak and more important based on environments and their impact is fluctuated.

There several management practices important to control insect pest and disease. Cultural practices such as sowing date, appropriate seed, field inspection, appropriate cultivation, crop rotation, cleaning the storage, use of resistance variety, biological control, botanical culture, integration of several control mechanisms and at last using of chemical important to overcome the problems of insect pest and diseases. The management system of farmers such as sowing date, crop rotation, appropriate cultivation and combination of several techniques crucial to avoid being attacked by diseases [52]. This review is prepared with the *objective* of major pests (insects and pathogens) of common beans, focusing on their host range, distribution, biology, ecology, and current management strategies, as well as the damage they causes of bean pests in Ethiopia.

2. Common Bean Botany, Origin, Distribution and Agro Ecology

Common bean (*Phaseolus vulgaris* L; 2n=22) is categorized under the genus of Phaseolus, species vulgaris. It is widely adapted and essential for food in rich with protein, minerals, and vitamins [27]. He was also reported, Common bean produced in several countries over the world. However, it is believed origin in South and Middle America, and diversified into Brazil and East Africa in the 17th century by the Portuguese. Similarly, it is believed to be introduced into Ethiopia in the same century by the Portuguese. Currently, substantial variations and genetic constituents developed. It is characterized morphologically and also used molecular characterization methods, and still under improvements. In addition, more than other species of legume and domestic crops, it known several variations of seed color of the crop varies from the small black wild type to the large white, brown, red, black or mottled seeds [67].

It has represents a wide range of life histories (annual to perennial), growth habits (bush to climbing), and complete reproductive systems, adapt wider agro ecologies [19]. It is widely germinated at altitude between 0-3000 *m.a.s.l* and adopted medium altitude with optimum temperature of 18-24°C and 500-1500mm of rainfall [49, 47].

3. Factors Impacts on Common Bean Increasing Production

Common bean is important and more diversified due to several things such as good sources of food, income, improver soil fertility, wider adaptation, early maturation, intercrop with stalk plant, etc. More, it is practiced in eastern and around rift valley of Ethiopia, during other crop affected due to dry spell, common sow while matured earlier than others, and little bit tolerate harsh condition. As a result, area of production and productivity steadily increased for las two decades. According to CSA, [24] the area covered by common bean production in Ethiopia in 2016 was 113,249.95 ha and 244,049.94 ha for white and red common bean respectively with total area of 357,299.89 ha and total production of about 540,238.94 tons/ha.

Even though, areas of production and it is use increases from year to year, it has constrained by several biotic and abiotic factors and easily susceptible to the entities or pathogens directly or indirectly. Demelash [27] reported that the most challenges of common production in Ethiopia is that absence of linked extension service, climatic change, biotic (insect pest and diseases) and abiotic factors. More, the issues of insect pest and diseases need attention due to endemic insect pest and disease emerging as factor of weather variability.

Biotic factors are diseases and insect pests. From several species of insect pest causes damage in common bean at pre and post harvest, the majors are listed in Table 1. The major economic important in common bean production in our countries are: Bean Stem Maggot (*Ophiomyia spp*), Aphids (*Acanthoscelides obtectus)* Weevils (*Zabrotes subfasciatus*) are significantly affects production and productivity. For instance, due to Bean stem maggot yield losses ranging from 30-100% have been reported. In addition, *Z. subfasciatus* and C. maculatus are the major pests of stored beans causing average grain losses of 60% within 3-6 months of storage period in Ethiopia (Demelash, 2018).

Similarly, common bean production could be constrained by diseases raised from fungus, bacteria, and viruses [14]. Commonly known common bean diseases are: Bean rust (Uromyces appendiculatus), angular leaf spot (*Phaeoisariopsis griseola*), anthracnose (*Colletotrichum lindemuthianum*), and common bacterial blight known in the country. For instance, bean rust causes yield losses up to 85%, while, Angular leaf spot impacts less quantified, but losses 70 to 80% of the production [71].

Evidences shows that divergent evolution of the pathogens has occurred in Africa, giving rise to pathotypes not found in Latin America [22]. Angular leaf spot, anthracnose, and common bacterial blight are major and widespread constraints to bean production at the regional and continental levels. Angular leaf spot is the most important biotic constraint in eastern and southern Africa; it is favored by moist, warm conditions with abundant in oculum supply A study on anthracnose was showed relatively more important at higher altitudes than at lower latitudes, while, bacterial blight was preferred moist and higher temperature condition [61, 15]. Recently, the most challenging disease and reported from several eastern and central Africa was root-rot species [55].

Table 1. *List of Major Insect pests in common bean.*

Common name	Scientific name	Status	Reference
Bean stem maggot	*Ophiomyia species*	Major	CIAT, 2005, Demelash, 2018
Aphids	*Aphis fabae*	Major	CIAT, 2005
Bean foliage	*Ootheca* spp.	Major	Abate and Ampqfo, 1995
Pod borers	*Maruca* sp. *Helicovepa armigera*	*Potential*	CIAT, 2005
Storage weevils (bruchids)	*Acanthoscelides obtectus* and *Zabrotes subfasciatus*	*Major*	Demelash 2018
Pod suckers	*Clavigralla* spp, *Riptortus* spp., *Anoplocnemis Nezara viridula*	Minor	CIAT, 2005
Semi-looper	*Trichoplusia* sp.	Minor	CIAT, 2005
Cutworm	*Agrotis* spp	Minor	CIAT, 2005
Trips		Potential	-

Source: CIAT, (final technical support, 2005).

3.1. Description of Major Insect Pests of Common Bean

3.1.1. Bean Stem Maggot

Bean Stem Maggot is known as bean flies which are frequently observed in the field of common bean in Africa. It has several species, but most common in bean field are only three species [12, 3, 2]. Ophiomyia *phuseoli, spencerella and centrosematis* are the most important of the three species. But majorities of tropical and sup-tropical Africa, Asia and Ausstralia damages by phuseoli and centrosematis, which can cause yield losses ranging from 80% to 100% [55].

(i). Morphology: Adults about 2 mm in length with a black body and large red eyes, the larvae is white, about 3-4 mm long. The Adult and larvae of Stem maggot described in Figure 1.

Figure 1. *Adult and maggot of Bean Stem Maggot taken from Ochilo and Nyamasyo, [55].*

(ii). Host Range**:** It has host in various legumes species, but frequently reported in common bean, and peas. It lay around 100 – 200 eggs.female^{-1} on damaged host leaves by maggots [2]. Later they enter the midrib, move into the stem and mine down to soil level, into the taproot. The feeding causes stems to form lesions wherein the maggots pupate, sometimes in small groups. Pest fecundity and longevity vary according to the specific host plant. The adult flies feed on plant secretions and on sap exuding from feeding holes. In the Middle East the pest completes several annual generations. It confirmed that more than 30 species of cultivated and wild plants in the family Leguminosae reportedly serve as hosts [37].

(iii). Biology: Adults of the three Bean stem maggot species have similar external morphological features, and male aedeagal characters are used to distinguish them. Puparia are distinguished by their color and by the characteristics of posterior spiracles [37] Puparia of O. *phuseoli* and *O. centrosematis* are brown, whereas those of 0. *spencerella* are shiny black, with a gray ventral surface. The posterior spiracles in 0. *phuseoli* are somewhat bifurcated and have eight to nine lobes; in 0. *centrosematis* they are blunt with three lobes [43]. Eggs of the pests are white, slender, and about 1 mm long, and laid separately each on different parts of the seedling.

The life cycle is completed between 20 to 30 days based on temperature of the around agro ecology [5]. Bean stem maggots at larvae stages causes damages on the seedling by feeding on the stem, which results in characteristic swelling and cracking just above ground level, then the seedling shows yellowish, wilted [3].

(iv). Ecology: The prevalence of Bean Stem Maggot species is heavily influenced by several climatic and edaphic factors and agronomic practices. Reports from many countries indicate that 0. *phaseoli* and *0. centrosematis* are more prevalent at lower altitudes and warmer climatic conditions, whereas 0.

spencerella is more abundant at higher altitudes and cooler, wetter environments [11]. For instances, 0. *phaseoli* is more common in early-sown beans, whereas 0. *spencerella* is the dominant species in late-sown beans [3].

3.1.2. Aphids (Aphis Fabae)

(i). Distribution and Importance: *Aphis fabae* is affected leguminous species in Africa, and more severe based on agro ecologies [42]. For instance, as reported by Karel and Rweyemamu, [44], Aphis craccivora causes damage at lowland areas on cow pea (Figure 2). They form colonies around the stem, leaves, and growing points and suck sap from plants which causes wilt and die [21]. This pest damages all parts, and makes stunted growth. Moreover, it has ability to transmit bean common mosaic virus (BCMV). More severe common bean around the stem, leaves and growing points as described in Figure 2 [43, 18].

Figure 2. *Adult Aphids and on host plants.*

(ii). *Biology:* Aphids fabae are approximately 2 mm long and very often carry a powdery white secretion on the abdominal segments at adult stage. In the moist agro ecologies, reproduction is only by parthenogenesis.

(iii). *Host range*: Aphids hosted multiple leguminous species. It adapts environments and weather variations in different techniques. For instance, wingless forms are produced when food is abundant and climatic conditions are optimal. However, when food is in short supply or the colony becomes overcrowded, winged forms develop. The winged aphids disperse to colonize new fields or plants and may invade bean fields soon after seedlings have emerged; however, damage to the pre flowering stage is more critical [48]. The aphid life cycle takes *11-13* days, and adult longevity varies from 6 to 15 days.

(iv). *Ecology:* Aphid more harmful and make visible during dry season, and thus infestations are more severe during the dry season. While, during moisture and humid weather, their colonies are often eliminated by members of the Entomophtoraceae [12]. There was secrete from Aphids called honedew augment the growth of sooty moulds and hence interferes with photosynthetic ability of the crops [13]. In different, plant attack by aphids reduces biomass, leaf area and relative growth rate of plan [65]. It is management frequently difficult, but some of cultural, biological, botanical reported in different regions, however, and using pesticides is very difficult due to complexity in life circle [13].

3.2. Major Diseases of Common Beans

3.2.1. Common Bacteria Blight

Several diseases cause production constraints in common bean production. Common bean light is the most popular disease causes yield losses of common bean up 10% to 45% depending on the environmental conditions and genotype [4, 35]. It is caused by the gram-negative bacterial pathogen *Xanthomonas axonopodis* pv. phaseoli (*Xap*) and its fuscans variant *Xanthomonas fuscans* subsp. *fuscans (Xff)* [34, 63]. The symptoms of both strain most similar, while Xanthomonas phaseoli var. fuscans often reported as more aggressive [56]. It often affects foliage, pods and seeds of common bean. This disease causes more severe in both yield and seed quality of bean when drought spell happen but moist condition often existed, and causes yield reduction at most 22.4% in Ethiopia [31]. Thus, it is considered as leading spread disease in the country [46]. Figure 3 showed the symptoms of CBB on leaf and pods of common bean.

Figure 3. *Interveinal necrotic symptoms with irregular yellow haloes, characteristic of bean Blight.*

Though CBB causes huge destruction and yield reduction in common bean, various crop management practices and agronomic activities can influence the incident and epidemics under field conditions [29]. Knowing host pathogen interaction, use of resistant varieties supplemented with chemical seed treatment and proper cultural practices could be also the best alternative options in managing common bacterial blight of common bean and avoiding yield losses [4].

Infection and host range: Infection occurs through natural openings such as stomata, cuticles and some wounds caused by mechanicals or other pests. Once inside the plant, the virulent multiplies rapidly in the intercellular spaces and it can take as little as 10-14 days from initial infection until secondary spread occurs [61]. The optimal temperature for infection to occur and also for disease development ranges 28°C to 32°C [64]. Therefore, CBB affected domestic and some wild legume species, while more revealed and economic important in common bean.

3.2.2. Angular Leaf Spot

Angular leaf spot (ALS) caused by imperfect fungus *Phaeoisariopsis griseola (*Sacc.) It is one of the most widely distributed and causes common bean yield reduction up to 80% (Schwartz *et al., 1981*). Often, the ALS revelation increased and spread by high speed over all common bean production area [68]. It is very harmful and diminishes production at suitable condition by defoliating leaf and lesion of the growth [53]. In addition, as it described in Figure 4, more preferred warm and moist condition, with more severe on leaves and pods of the common bean [61].

Figure 4. *Angular leaf spot infection (at pod and leaf).*

4. Control Measures

4.1. Agronomical Practices

Even though common bean production is most popular and covered wide ranges of small scale farmers and agro ecologies, host ranges and effects of diseases and insect pest diminishing if not control methods interfere [58]. Abate and Ampofo, [1] reported as methods of production uses as barrier of insect pests to score economic loss; for instance the common bean cultivated solely was more affected than intercropped since in the past twenty years. This condition might be help to enhances natural enemy abundance during intercrop in the same field. This observation indicated that several agronomic practices have been finger print in reducing the economic losses may happen in common bean production by pests.

Appropriate agronomic practices started from site selection, crop rotation, and cultivar and seed selection, preferential sowing date, and intercropping might have a certain degree to reduce the infestation of certain insect pests. For instance, Acreman and Dixon, [6] reported early sowing has positive effects on production improvements while negative for aphids effects. Specifically, Aheer *et al*. [7] observed the effect of sowing date on population of ootheca, bean stem maggot, aphids and other arthropods attacking common beans. On the right hand, late sowing and offseason planted causes highest infestation of bean stem maggot [54].

In other agronomic studies, row spacing and plant density, weed control and stubble retention have been used to control bean stem maggot [54]. Even, horizontal plows with protecting hedges at the border of the field reduced wind speed which promoted aphids and *Ootheca* distribution [20].

Optimum to higher plant density has positive effects into decreased 10% - 20% common bean virus incidence transmitted by aphids [69]. Forbes et al. [33] described the use of straw and mustard mulches which can reduce bean stem maggot up to 80%. Since these methods are safe and cheap, there is a need of conducting detailed research to understand mechanism involved in providing protection and hence advocating well their usage.

4.2. Biological Control

Biological control is simply the way of managing harm full insect pests and disease with help of other organisms [32]. Biological control organisms used several techniques such as predation, parasitism, herbivore, or other natural mechanisms [32]. The objective of biological control is not total destruct the species, while minimizing pest population and keep and economic threshold [41, 17]. For instance, all species in the braconid subfamily Aphidiinae develop as endoparasitoids (inside) of aphids with one larva completing development in each host. Some species of entomopathogenic fungi infest aphids through the cuticle eventually killing the host. Lady birds are stronger, larger, and usually more intelligent than the prey and may attack several hosts in a short period [26].

The other biological control reported by Copping and Menn, [23] is Spinosad is another biological control of aphids which is a biologically derived insecticide produced by the actinomycete *Saccharopolyspora spinosa*, a bacterial organ isolated from the soil. It is affect stomach and poisoning nerve of pests [10]. Spinosad is recommended for the control of a very wide range of caterpillars, leaf miners and foliage-feeding beetles [23]. Other known biological method is the use of *Bacillus thuringiensis* to control lepidopteron larvae, including *Helicoverpa* spp., *Spodoptera* army worms, diamondback moth *Plutella xylostella*, and *Chrysodeixis loopers* in legumes [69]. Biological control is safe and eco-friendly. Therefore, more research is needed to develop bio control packages in controlling common bean insect pests. Once achieved and upscale, this will provide sustainable solution in plant protection programmes.

4.3. Botanical Pesticides Control Methods

Botanical methods extracted from different parts of plants uses as Pesticides have great potential for impact in developing countries [51, 9]. It is more sustainable and has low environmental impacts as compared to chemical pesticides. Typically, it comprises a mixture of bioactive compounds with many advantages in terms of efficacy short span and preventing the development of resistance [45]. They are mostly affordable to farmers than synthetic products and their costs are almost calculated in terms of time to harvest and process [16].

Several botanical controls locally known and widely practiced during inn the 17th century, pyrethrum, nicotine, and rotenone were recognized as effective insect control agents [57, 36]. In addition, Nicotine isolated from number of species of *Nicotiana,* tobacco extract, neem oil and extract have promising and useful for common bean pest control [39, 60]. Several locally available botanicals extracts known are Vernonia, crotons, Eucalyptus globules, etc [57]. Due to the need for the alternative to synthetic insecticide, it is therefore essential to evaluate the potential of locally practices such as those involving agronomic, biological, and botanical practices in controlling legume insect pests.

4.4. Chemical Control Methods

The world agricultural production widely practices all in all areas of crop cultivation at different level practices. The level of chemical application and uses more at where larger number of investors and larger scale production to control disease and insect pests. As a result, worldwide it is estimated that approximately around one billion or 27% of world worker people engage in agriculture and most use pesticides to protect food and commercial products that they produce [28]. The annual cost required for chemical was around six billion pounds as worldwide.

Several national bean programs and other research organizations in the globe have identified important chemicals uses during sowing and at storage. The most often recommended were: endosulfan, diazinon or lindane that can be applied at low doses as seed dressing to provide protect from vulnerable to attacks especially bean stem maggot before sowing period [62]. The other chemical such as Imidacloprid recommended for aphid and reduces effects of bean leaf roll virus, leaf necrotic yellow virus and dwarf virus in soybean [69]. The author Songa [66] reported soil fumigation chemicals such as Triazopho, chlopyrfos, and Fenvalerate can be used in controlling bean stem maggot.

Chemical control may effective and valuable to increase crop production. The most challenge with in current climate variability and quality production deterioration. Further, in most of small scale farmers in developing countries less chance to get chemicals even in seldom very crucial to use it. To minimize such problems, individual organization responsible for seed production and afford healthy seed as similar to other crop is very legal and required for common bean and other legume species crops.

The other factors should be considered in chemicals application and its system is less awareness of farmers how to use, and dispose the materials. Stuart [70] reported that chemicals have limited application rules in rural areas, often adultered or applied at inappropriate application rate due to illiteracy, poor labeling or use of old, expired products and lead to rapid evolution of pesticide resistance. In the study additional reports that of residues effects in environmental impacts to wild life, crop pollinators and natural enemies are also severe. Thus, huge scared happened in the society for human health by use of chemicals with no mechanism to ensure food safety for consumers, and concern for the chronic effects of exposure [40]. The most often priority given for biopesticides as alternatives considering the issues of organic production food and environmental pollution minimizes [59]. Therefore, even though chemicals recommended at last option and critical period, it will be use most probably to increase longevity of seed and select those confirmed best to health benefits to the applicators, consumers and the environmental is recommended.

4.5. Integrated Pest Management Method (IPM)

One real thing should be known by producers and even users are any crop had enemies which are called at most disease and insect pests, but in seldom vertebrate animals. Those enemies' severities and intensities different from crop to crop. To minimize the effects of pests, users use several control methods intentionally or arbitrary. Most of cultural methods used as pest control, but they implement for different things. The issue of integrated pest management is relative to these issues. The process of crop managements of integrating two or more recommended crop protection technology is called integrated pest management. This method is more preferred and practices directly by intention and at most parts of small scale farmers practices without the purposes of integration. It is highly recommended due to several important elements. 1) Integrated pest managements is conserve multi species of organisms fauna and flora. 2) It has reality of eco friendly and reduces environmental

Pollution. 3) More or less, IPM is economically affordable and easily practiced by small scale farmers. 4) It is familiarizes the producers with several new crop protection technologies within short period of time. Furthermore, the issues rose in chemicals as problem that is cost of purchases and environmental pollution easily solved by integration crop managements system. The other advantage is mostly, the technologies are modified cultural practices practiced among the farmers, but they didn't well known its purposes.

5. Conclusion

Common bean is widely agro ecological adaptation. Due to this, chances to affect by pest of several species are more than specific agro ecology adaptation crops. In addition, it has opportunity to have huge host ranges for pests. Major identified diseases and insect pest which are economic importance's for common beans were discussed in this study. Those need managements at different levels and intensity. The problem of diseases and insect pest infestation in common bean take into consideration at national programs and other research organizations. Those responsible bodies developed appropriate from convectional to latest management methods. However the most important issues during the management's appropriate strategy, identification of biological life cycle in depth, host ranges, time of infestation and economic losses are the most pre required in the pest managements. In addition, the issues of areal pollution or environmental friendly and increasing sustainability of the biotic mutuality is any time and at most get first priority. Based on these; cultural practices, botanical, resistance varsities, biological control methods and integrated pest management methods raised and given first priorities. Based on the occurred severity, the last option recommended control method is chemicals under the supervision or managements of experts that can be applied at low doses to provide protection at a time when they are most vulnerable to attacks.

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