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Impact of Sex-Limited and Alary Polymorphism on Spermathecal Diversity and Reproductive Behaviour in some Mycophagous Tubulifera (Insecta: Thysanoptera)

K DHILEEPAN and T N ANANTHAKRISHNAN
Entomology Research Institute, Loyola College, Madras 600 034

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Structural diversity of the spermatheca as well as behavioural diversity in the reproduction of some mycophagous Tubulifera are presented alongside with the mating patterns, involving sex-limited polymorphism, with reference to four species of sporophagous thrips viz., *Tiarothrips subramanii* (Ramk)., *Elaphrothrips denticollis* (Bagnall), *Elaphrothrips procer* Schmutz, and [1]*Adelothrips cracens* (Anan.).

Key Words: Polymorphism, Thrips, Spermatheca

Introduction

The degree of reproductive diversity among individuals reflects significant variations concerning vitellogenesis, pre-oviposition, oviposition and post-oviposition periods, fecundity and embryonic nourishment. Polymorphism, whether sex-limited polymorphism or reproductive polymorphism or both, also appears to have an equally significant impact on mating preferences by both sexes, fecundity as well as on life cycles. Further, striking secondary sexual characters occurring in the polymorphs of one or both sexes enable competition among the sexes for choice of mates. Ananthakrishnan et al. (1983) have outlined several such aspects of eco-behaviour, as the degree of aggregation, mating preferences etc., as well as the complexities involved in the life cycles of several species, notably the pre-oviposition, oviposition, post-oviposition periods as well the influence of environmental factors in determining the types of reproduction (Ananthakrishnan et al. 1983, 1984, Ananthakrishnan 1986). Observations presented here pertain to the structural diversity of spermatheca as well as behavioural diversity in the reproduction of some mycophagous Tubulifera.

Material and Methods

The different sporophagous species were collected from their respective fungus infested hosts and maintained in a BOD incubator at 27±1°C and 80% RH. Individual thrips as well as mated pairs were reared in plastic vials (4.5×3.0 cm) containing the specific fungal meal. The mouths of the rearing vials were covered with muslin cloth for aeration. Cotton plugs soaked in water were kept in each culturing vial for moisture, and these cotton buds were moistened periodically.

For histological studies, standard protocols have been followed. Mating patterns involving diverse breeding combinations between different sex-limited polymorphs were studied by freely allowing individuals to mate and the mating pairs as such were carefully transferred to a different vial and observations on the oviposition behaviour and fecundity were made.

Results

Spermathecal Diversity

The structural profiles of the spermatheca are highly variable within the same species irrespective of their type of reproduction as well as in the same individual depending upon the number of matings it has undergone. In *Tiarothrips subramanii* the saccular spermatheca varies in shape and size depending upon the number of times it has mated and the amount of spermatozoa it stores. Histologically an unmated spermatheca consists of a thin muscular layer with single layer of columnar epithelial cells with a centrally placed nucleus and dense cytoplasm. The whole spermatheca is hollow in mated females, and it reveals

[1]Now transferred to the genus *Holothrips*

the presence of a large number of spherical, cuticular capsule-like structures filled with spermatozoa, the heads of the latter being oriented towards the centre. The capsules appear to consist of thick muscle layers which appear cuticularised. The number of such spherical bodies containing the spermatozoa ranged from 5 to 6. After utilization of spermatozoa for fertilization, the spherical bodies become empty with the cuticular layers approximating each other so as to appear as two-layered. Since it is well known that no spermatophores are produced and only the spermatozoa are passed and stored in the spermatheca of thrips, the entire process of the secretion of the cuticular covering for spermatoza should hav. taken place only within the spermatheca, the exact process involved being not known. It is possible that the outer epithelial cells of spermatheca have a role in secreting this cuticular lining. Similarly the exact process by which the spermatozoa are released back into the common oviduct from the cuticular spheres for fertilising the oocytes is also not clear. Incidence of severai, intact, but empty cuticular spheres indicates that these cuticular coverings are not completely dissolved or digested to release spermatozoa for fertilization (plates 1 & 2).

In *Elaphrothrips procer* also a similar spermatheca is evident, each with 5 to 17 cuticular spheres. The length and width of the spermatheca do not considerably differ among different types of ovaries and ranged from 371 to 520μ and 148 to 159μ respectively. However, the number of cuticular spheres containing the spermatozoa range from 12 to 17, 9 to 12, and 4 to 7 in the spermatheca of viviparous, ovoviviparous and oviparous individuals respectively. Histological studies reveal a similar structure in which the spermatozoa in groups are completely surrounded by a thick layer of cuticle-like structures (plate 2). The number of cuticular spheres with spermatozoa are very high in viviparous forms, low in oviparous forms indicating its higher utilization ability in oviparous forms than ovoviviparous and viviparous forms.

In *Bactrothrips idolomorphus*, the spermatheca is very long with the distal blunt end broader than the proximal narrow end. The spermatheca is larger in oviparous, comparatively smaller in ovoviviparous and viviparous forms. In *Loyolaia indica* the spermatheca is very small during its reproductive stage, whereas during the reproductive diapause state the spermathecae are very much enlarged, mainly due to the storage of spermatozoa which are not utilized for fertilization.

Mating Frequency

In a colony of *Tiarothrips subramanii*, higher number of mating attempts were made by oedymerous males towards major females, whereas fewer number of mating attempts were made by oedymerous males towards normal females. The number of females rejecting the males varied considerably depending upon the type of polymorphism. Similarly the total number of mating attempts as well as the percentage of unsuccessful mating varied greatly depending upon the type of polymorphs involved in mating.

In *Elaphrothrips procer*, maximum mating attempts were made by oedymerous males towards major females and normal females, whereas normal males made less frequent attempts towards major females and normal females. Like normal males, gynaecoid males also made less frequent attempts with major females and normal females. The major females preferred the normal males than the oedymerous males and lesser preference towards gynaecoid males, whereas the normal females preferred gynaecoid males more than the oedymerous males. An analysis of the mating patterns is provided in tables 1-4.

Mating Patterns Among Sex-limited Polymorphs

Reproductive compatibility was evident in many of the mycophagous Tubulifera showing sex-limited polymorphism. Such mating patterns or diverse breeding patterns involving diverse fecundity rates due to polymorphism is further complicated by the occurrence of reproductive diversity, namely oviparity, ovoviviparity and viviparity. Mating patterns involving breeding between different polymorphs among four species of sporophagous idolothripines, viz., *Tiarothrips subramanii, Elaphrothrips denticollis, Elaphrothrips procer* and *Adelothrips cracens* indicated a significant variation in the fecundity due to the sex-limited polymorphism. In each type of reproduction, fecundity rates tend to vary, according to the mating patterns involved. Particular mention may be made of *Adelothrips cracens*, which is mycetophagous while inhabiting the dry fungal infested twigs of *Solanum trilobatum* and showed apterous, brachypterous and macropterous forms which reproduced by oviparity. The same species when inhabiting the fungi infested leaves of *Borassus flabellifer* is sporophagous as evidenced by the gut spore analysis and exhibited only macropterous and apterous forms which were oviparous, ovoviviparous and viviparous. As such, the fecundity rates were highly variable depending upon such factors as the type of reproduction, sex-limited polymorphism, type of fungal food, and alary polymorphism, with each of them closely linked with one another, resulting in complex life cycle patterns. Thus, in general, the fecundity was very high in oviparous, comparatively lower in ovoviviparous, and very low in viviparous forms. In each type of reproduction the fecundity rate: vary further with the type of mating pattern—the fecundity was high between oedymerous male and major females and very low between gynaecoid male and normal female. In such cases in each type of

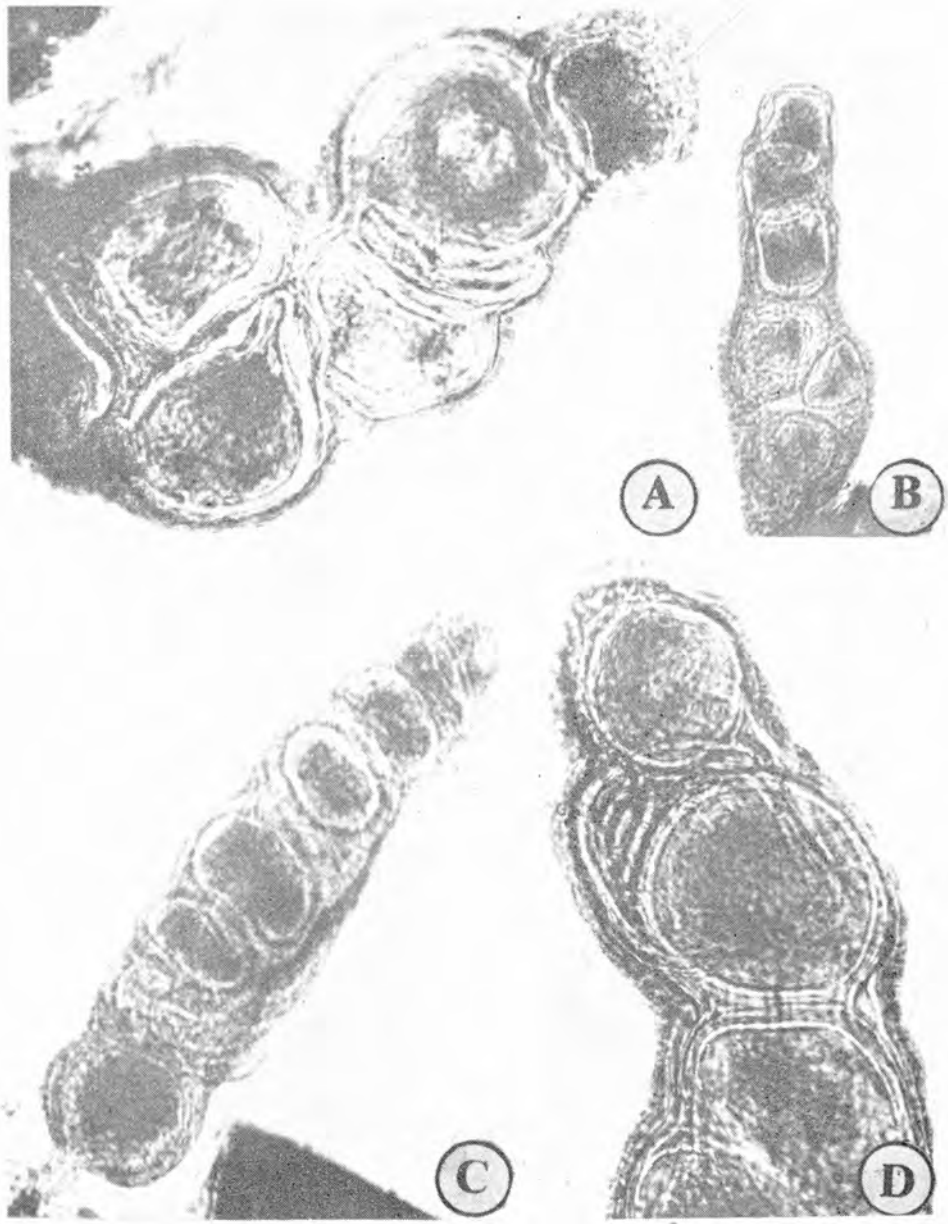

Plate 1 (Figures A-D). Spermatheca (entire) showing variations in the number and nature of cuticular spheres in Tiarothrips; **A,** *Spermatheca* of ovoviviparous form; **B,** *Spermatheca* of oviparous form; **C,D,** Englarged views

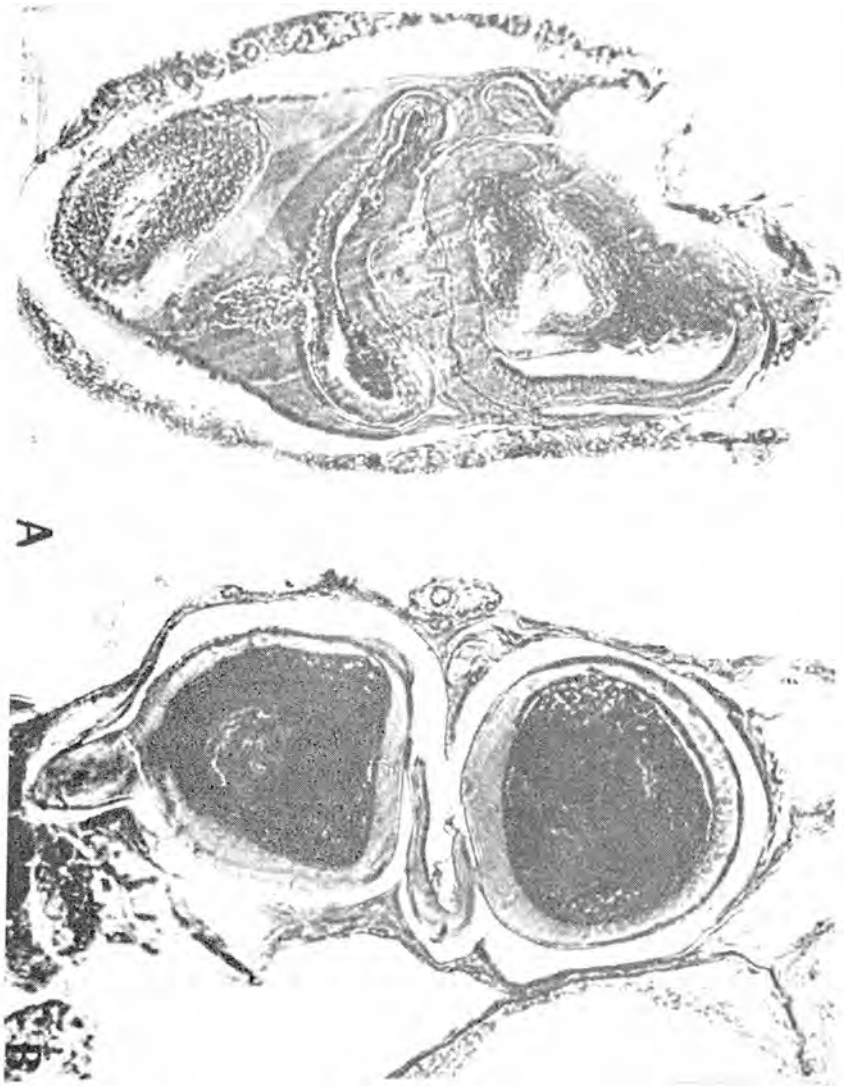

Plate 2 (Figures A-B). A, L.S. spermatheca of Tiarothrips showing empty cuticular spheres; **B,** L.S. spermatheca of Tiarothrips

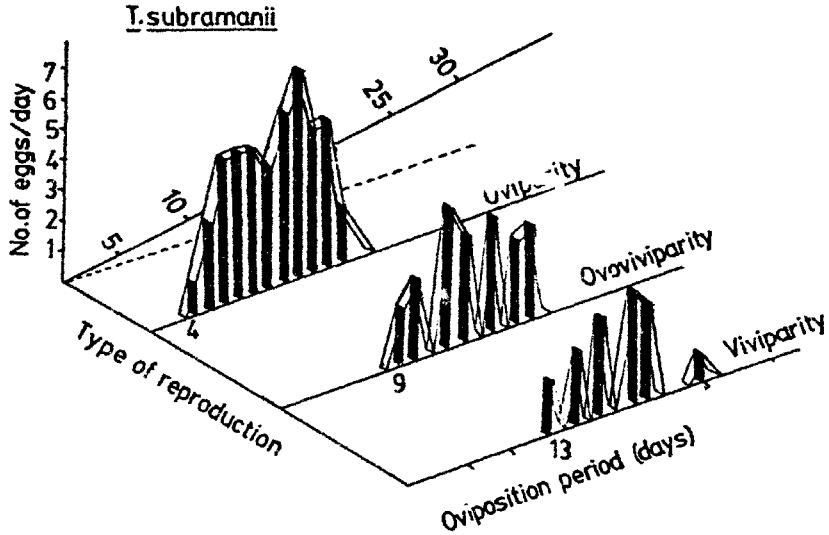

Figure 1 Reproductive potential of *Tiarothrips subramanii*

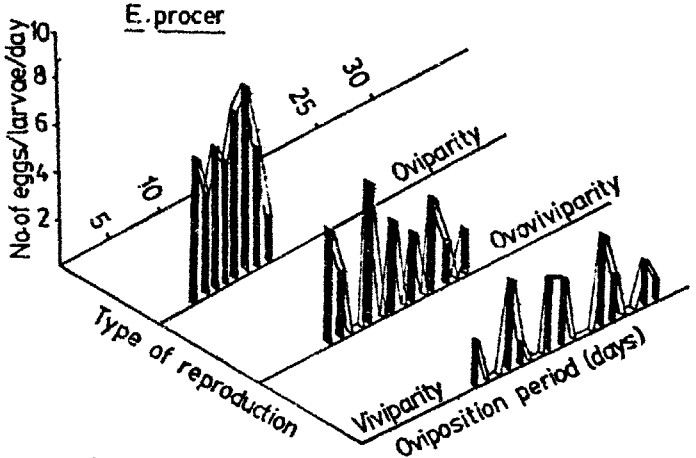

Figure 2 Reproductive potential *Elaphrothrips procer*

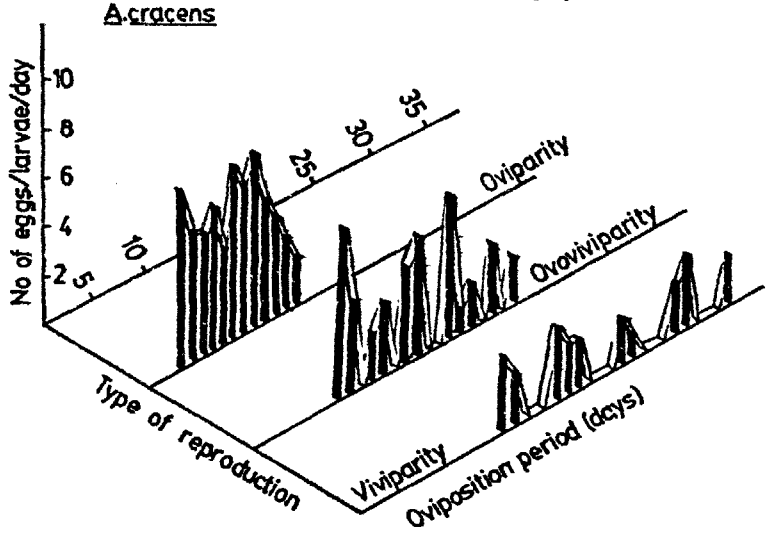

Figure 3 Reproducti e potential of *Adelothrips cracens*

Table 1 *Mating Patterns in* Tiarothrips subramanii

Mating Patterns	Fecundity		
	Oviparity*	Ovoviviparity*	Viviparity**
Oedymerous male vs Major female	42.6±2.01 (37–48)	33.2±2.45 (25–39)	22.0±1.30 (19±26)
Oedymerous male vs Normal female	29.2±2.08 (24–36)	21.2±3.83 (14–26)	15.6±1.53 (13–21)
Normal male vs Major female	23.2±2.65 (17–31)	20.4±2.08 (19–27)	16.6±1.12 (14–19)
Normal male vs Normal female	21.6±0.60 (20–23)	16.2±1.39 (12–19)	11.2±0.66 (6–10)
Gynaecoid male vs Major female	17.8±1.24 (16–21)	11.4±0.67 (9–13)	7.6±0.81 (9–13)
Gynaecoid male vs Normal female	14.6±0.60 (13–16)	11.2±0.66 (9–13)	5.2±1.46 (3–11)

Mean ± S E
Figures in parenthesis indicate range
Mean of 5 replicates
Between mating patterns–8.52
Between type of reproduction–9.13
Mating pattern vs Type of reproduction–3.25

* No. of eggs/female
** No. of larvae/female
CD at 1% level

Table 2 *Mating patterns in* Elathrothrips denticollis

Mating Patterns	Fecundity		
	Oviparity*	Ovoviviparity*	Viviparity**
Oedymerous male vs Major female	55.6±8.93 (43–66)	24.4±3.91 (19–28)	16.0±2.33 (13–19)
Oedymerous male vs Normal female	38.6±4.66 (32–44)	30.0±4.94 (26–38)	22.6±3.97 (18–28)
Normal male vs Major female	44.6±3.97 (39–48)	25.4±4.50 (20–32)	15.4±2.30 (12–17)
Normal male vs Normal female	29.4±4.82 (21–33)	18.6±4.15 (13–23)	16.4±2.07 (14–19)
Gynaecoid male vs Major female	35.0±3.16 (31–39)	17.4±3.43 (14–22)	10.2±3.11 (6–13)
Gynaecoid male vs Normal female	22.6±4.03 (18–27)	16.6±1.51 (15–19)	8.0±3.00 (4–11)

C.D. at 1% level
Between replication = 2.08
Between mating patterns = 7.02
Between type of reproduction = 18.09
Mating pattern vs Type of reproduction = 3.64

Mean ± S E
Figure in parenthesis indicate range
Mean of 5 replicates
*No. of eggs/female
**No. of larvae/family

Table 3 *Mating Patterns in* Elaphrothrips procer

Mating Patterns	Fecundity		
	Oviparity*	Ovoviviparity*	Viviparity**
Oedymerous male vs Major female	43.6±2.97 (37–52)	26.6±1.60 (23–31)	15.0±1.78 (11–21)
Oedymerous male vs Normal female	34.2±1.06 (31–37)	22.6±0.67 (21–24)	14.4±1.63 (11–20)
Normal male vs Major female	34.6±2.31 (29–41)	22.2±2.08 (17–29)	4.4±1.56 (9–18)
Normal male vs Normal female	26.6±1.12 (22–39)	18.8±0.08 (17–23)	11.0±0.66 (8–13)
Gynaecoid male vs Major female	27.0±2.00 (22–33)	19.2±1.11 (17–23)	11.0±0.83 (8–13)
Gynaecoid male vs Normal female	21.0±0.75 (20–24)	11.8±0.86 (9–14)	8.8±0.58 (7–10)

C.D. at 1% level
Between mating patterns = 0.75
Between type reproduction = 13.77
Mating pattern vs type of reproduction = 1.89
*No. of eggs/female

Mean ± S E
Figures in parenthesis indicate range

Mean of 5 replicates
** No. of larvae/female

Table 4 *Mating patterns in* Adelothrips cracens

Mating Patterns	Fecundity		
	Oviparity*	Ovoviviparity*	Viviparity**
Oedymerous male vs Major female	58.2±6.30	40.4±4.39	21.0±2.00
Oedymerous male vs Normal female	39.8±2.77	23.8±2.28	16.0±2.44
Normal male vs Major female	47.8±4.20	29.2±6.01	18.8±2.48
Normal male vs Normal female	31.6±1.94	24.8±3.89	12.4±0.89
Gynaecoid male vs Major female	23.4±3.28	14.0±1.22	8.8±1.48
Gynaecoid male vs Normal female	15.6±2.30	9.4±1.14	7.0±1.22

Mean ± S E
C.D. at 1% level
Between mating pattern = 11.77
Between type of reproduction (fecundity) = 17.128

Between mating type vs Type of reproduction = 3.37
* No. of eggs/female
** No. of larvae/female

breeding pattern the fecundity seems to vary with the types of alary polymorphism (figures 1–3).

Discussion

Females investing in fewer young ones should in general maximize their reproductive success by discriminating about the quality of the contributor to the genotypes of their young (Williams 1966). In the four species of mycophagous Tubulifera studied viz., *T. subramanii*, *E. procer*, *E. denticollis*, and *A. cracens*, fecundity was highest when mating occurred between parental oedymerous male and major female, and it was lowest when a gynaecoid male mated with the normal female. However in the majority of species it was highest in oedymerous males and major females. This is supported by the observations of Price (1973) who suggested that the variations in the number offfsprings produced per reproductive period occur in closely related species or within a single species, in a number of diverse groups. Such a polymorphism involving a range of diversity are related to the variety of ecological characteristics and have a complex relationship with the reproductive rate of these polymorphic organisms (Hespenheide 1973). Thus it is cleary evident that in spite of the varying grades of sex-limited polymorphism greatly influencing the mating behaviour and sexual selection, all these polymorphs are reproductively compatible and can successfully propagate the progeny, but with varying reproductive rates. Since, the success of an organism is generally assessed in relation to their reproductive efforts, it can be presumed that the oedymerous forms showed higher reproductive efforts in *E. denticollis*, *E. procer*, *T. subramanii* and *A. cracens*.

In addition, fecundity also varied depending upon the alary polymorphism. In *A. cracens*, the fecundity seems to be higher in apterous forms, and very low in macropterous forms and an intermediate range occurs in between these two combinations. Thus fecundity is reduced as it progresses towards the macropterous forms in which it is presumed that much energy is diverted for active dispersion resulting in reduced fecundity.

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