中央農研研究報告 9：17−74（2007）
Bull. Natl. Agric. Res. Cent.

Population Dynamics of *Leptocorisa chinensis* (Hemiptera: Alydidae) and Forecasting of Damage Occurrence in Rice Fields

Hiroaki Takeuchi*

Summary

Rice bugs are considered to be important pests of rice in Japan. When rice bugs infest a spikelet, brown or black marks appear on the grain. These stained grains are called pecky grain. Hulled rice grains that contain over 0.1% of pecky grains have reduced commercial value according to Japanese rice quality regulations. *Leptocorisa chinensis* Dallas is a major rice bug species in central and western regions of Japan. Recently, the prevalence occurrences and distribution area of this species have been increasing. Furthermore, there have been increases in the number of areas where the severity of pecky grain contamination damage has intensified compared to previous records. In this study, to clarify the reasons for the recent high prevalence of *L. chinensis* and methods to forecast pecky rice contamination damage, 1) Population dynamics and mortality factors of *L. chinensis* and 2) Feeding characteristics of rice bugs and modeling of the relationship between the density of *L. chinensis* and the probability of damage occurrence were investigated. The results obtained in each chapter are summarized as follows.

1. Population dynamics and mortality factors of *L. chinensis*

1) Overwintering adults of *L. chinensis* appeared in grass fields in southern Ibaraki Prefecture from late June to early July. Their progeny appeared soon after, and the subsequent population fluctuation was bimodal. In contrast, overwintering adults of *Cletus punctiger* appeared much earlier, in early May, while the next-generation nymphs were seldom observed until late June. Based on the immigration dates of overwintering adults and the cumulative effective temperature for development and ovarian maturation, it was confirmed that *L. chinensis* is bivoltine in the study area. Peak occurrence of *L. chinensis* adults in grass fields did not coincide with the heading date of mid-season rice cultivated most widely in southern Ibaraki Prefecture. This reveals that current rice cultivation practices in this area are suitable to prevent the massive invasion of *L. chinensis*.

2) Using cages set in rice fields, the relationship between the number of *L. chinensis* and the number of pecky rice grains were investigated. Eggs of *L. chinensis* were released, in number ranging from 6 to 36, into 1.6×1.6×1.5m cages at the milk ripening stage in a rice field. The number of pecky grains was highly correlated with the number of hatched nymphs and the number of individuals (both of adults and nymphs) at harvest, but not with the number of eggs released. Furthermore, the number of hatched nymphs was highly correlated with the number of individuals at harvest, but not with the number of eggs released. The egg survival rate was bimodal, with peaks at 0-20 or 80-100%, suggesting that predators caused an all-or-nothing type mortality to the eggs masses. These results indicate that an estimation of the density of hatched nymphs is more important than those of immigrant adults for obtaining a highly accurate estimation of pecky rice damage in rice fields.

3) To clarify factors causing mortality of *L. chinensis* eggs, sentinel egg masses were exposed at intervals of four days in two gramineous weed areas, a rice field, and a soybean field, from July to September. Parasitized eggs occurred in the retrieved sentinel egg masses in the four areas. The peak parasitized egg ratio was 30%, 70% in the each of the two gramineous weed areas, respectively, 9% in the rice field, and 42% in the soybean field. Some

Received 12 June 2006; Accepted 6 December 2006

* National Agricultural Research Center for kyushu Okinawa Region

missing eggs also occurred in the four areas. The peak missing egg ratios were 56%, 73%, 50%, and 67%, respectively. These findings indicate that *Gryon japonicum* and egg predators are major mortality factors of *L. chinensis* eggs.

4) Trial sentinel eggs, application of insecticides, and field censuses were employed to clarify the species of *L chinensis* egg predators in the two rice fields that had been transplanted on 23 April (Field B) and 10 May (Field A). The average numbers of hatched and missing eggs did not differ significantly between the sprayed and control plots in field A. In field B, however, the numbers were significantly different. The percentage of missing eggs in damaged egg masses ranged from 80-100%. In the laboratory, we found that the feeding marks caused by the meadow grasshopper, *Conocephalus chinensis,* have characteristics that are similar to those on the eggs exposed in the rice fields. The density of *C. chinensis* was low in control plots of Field A. In contrast, the density was high in those of Field B. These observations suggest that the density of egg predators, e.g. *C. chinensis,* was a mortality factor of *L. chinensis* eggs in rice fields.

2. Feeding characteristics of rice bugs and modeling of the relationship between the density of *L. chinensis* and the probability of damage occurrence.

1) Feeding marks on grains were investigated to clarify species specific characters. The feeding marks caused by *L. chinensis* and *Lagynotomus elongatus* were mostly found on the grain surface along the hooking portion and the basal part of the grain, respectively, while those caused by *C. punctiger* were found everywhere under lemma and palea. The position of the feeding marks on rice grains was species-specific, and independent of the ripening stage of the rice and the developmental stage of rice bugs. These results provide useful information for specifying the major species causing the pecky rice.

2) To clarify the ripening stages of spikelets preferentially attacked by *L. chinensis, L. elongatus, C. punctiger,* and *Stenotus rubrovittatus* in paddy fields, rice bugs were individually released for three days onto a rice panicle at various stages of maturation (7, 14, 21 and 28 days after heading, DAH). The spikelets were classified into three groups, Group A (early flowering), Group B (mid-flowering), and Group C (late flowering), according to the position in a panicle, which is closely related to the flowering order. The bugs chose to feed on the spikelets in Group A and Group B on 7 DAH. At 14 and 21 DAH, however, bugs preferred the spikelets in Group C to those in the other two groups. In *L. chinensis, L. elongatus,* and *S. rubrovittatus,* the total number of damaged spikelets decreased with maturation of the panicle, whereas there was no remarkable change in the number of spikelets damaged by *C. punctiger.* These results suggest that all species of rice bugs except *C. punctiger* selectively damage spikelets of ovaries are developing with lengthwise to sidewise elongation, whereas *C. punctiger* mainly attacks spikelets of ovaries developing with lengthwise to thickness elongation.

3) To clarify the relationship between the occurrence patterns of *L. chinensis, L. elongatus* and *S. rubrovittatus* and the developmental stage of panicles in rice fields, we observed the development of spikelets in three paddy fields. Spikelets were classified into three stages based on ovarian development: Stage I (initial), Stage II (middle), and Stage III (fullness). Variations in the average number of each stage of spikelet development among the three plots expressed in cumulative degree-days were smaller than those expressed in days after the initial heading stage. The peaks of adult incidence were near the peak of Stage I at 50-150 degree-days. The incidence of nymphs began to increase near the peak of Stage II at 200-250 degree-days. The occurrence patterns of all the three rice bug species were found to be closely related to the abundance of the three stages of spikelets. Cumulative degree-days can be used to uniformly express the changes in the incidence of rice bugs among different rice varieties, seasons, and fields.

4) In order to clarify the effect of split-hull paddy on the ratio of pecky rice grains caused by *L. chinensis,* we carried out an experiment using cages set in rice fields where two rice varieties, 'Akitakomachi' or 'Hitomebore' were

transplanted. The ratio of split-hull paddy was about 5% in Akitakomachi and 1% in Hitomebore. The numbers of pecky grains per 1000 hulled grains did not differ significantly between the two varieties. These results indicate that the split-hull paddies tend to be infested by *L. chinensis*. However, when the split-hull ratio is less than 5%, the ratio of pecky rice grains does not show a remarkable increase.

5) To estimate the occurrence of pecky grain damage caused by *L. chinensis* in rice fields, I constructed 30 logistic regression models using the data obtained from field censuses. The explanatory variables of each model were: different combinations of rice variety, date of initial heading stage, number of adults at early ripening stage, and numbers of adults, nymphs and their total at the mid-ripening stage. Akaike's information criteria indicated that a model whose explanatory variable was the number of nymphs at the mid-ripening stage was statistically better than the other models. These results suggest that a census of nymphs at the mid-ripening stage, which is 200-300 day-degrees from the initial heading stage, is an appropriate way to estimate the occurrence of pecky grains

摘 要

斑点米カメムシ類とは，イネの穂を吸汁加害し，玄米に黒～褐色の斑紋を生じさせるカメムシ類の総称である．斑紋が生じた米粒は，「斑点米」と呼ばれる．玄米中へのわずかな斑点米の混入（0.1～0.7%）が，品質低下の重要な要因のひとつとなる．クモヘリカメムシは，東北以南の太平洋側から西日本全域に分布する斑点米カメムシ類の重要種であり，近年多発生の傾向にある．しかし，本種の発生動態に関する知見は非常に少ない．また，防除対策を決める際に利用できる被害予測方法はまだない．そこで本研究では，茨城県南部におけるクモヘリカメムシを中心とした斑点米カメムシ類の発生動態，密度変動要因を明らかにするとともに，加害生態の解明ならびにクモヘリカメムシの密度と斑点米被害発生確率との関係のモデル化を行った．

①クモヘリカメムシの発生動態と密度変動要因の解明

イネ科牧草・雑草上におけるクモヘリカメムシの発生動態を同所的に生息するホソハリカメムシと比較しながら調査した．クモヘリカメムシの越冬世代成虫は，6月末から7月上旬にかけて出現した．そのすぐ後に第1世代幼虫が出現し，10月までに2回幼虫の発生ピークが現れた．一方，ホソハリカメムシの越冬世代成虫は5月はじめにはすでに発生が認められたが，幼虫は6月下旬～7月中旬までほとんど発生せず，その後もクモヘリカメムシほど明瞭な個体数ピークは観察されなかった．クモヘリカメムシの出現開始時期および有効積算温度から，本種は茨城県中南部では年2世代発生すると推定した．本地域でのコシヒカリは耕種的にはクモヘリカメムシの被害を受けにくい時期に作付けされていると考えられた．

水田内でのクモヘリカメムシの自然発生密度は通常非常に低い．そこで，水田に設置した網枠内にクモヘリカメムシの卵を放飼することにより，水田におけるクモヘリカメムシの密度と斑点米発生数との関係を調査した．放飼卵数に対する斑点米発生数の変動は大きく，決定係数の高い回帰式は得られなかった．卵期の死亡要因が放飼卵数と斑点米発生数の主要な変動要因であり，クモヘリカメムシによる斑点米発生数の予測には，侵入成虫密度の推定よりもふ化幼虫密度の推定が重要であると考えられた．

開放系の水田，ダイズ圃場，圃場外のイネ科雑草群落において，クモヘリカメムシ卵を用いたおとり法によって調査して，ヘリカメクロタマゴバチと捕食性天敵がクモヘリカメムシの卵期の主要な死亡要因であることを明らかにした．さらに，水田ではおとり法と農薬散布による天敵除去法を組み合わせて調査して，クモヘリカメムシの卵期の主要な捕食性天敵は，ウスイロササキリであり，その働きには水田間の違いが認められることを明らかにした．

②斑点米カメムシ類の加害生態の解明とクモヘリカメムシの密度と斑点米被害発生確率との関係のモデル化

籾における加害部位にカメムシの種による特異性を認め，クモヘリカメムシでは鉤合部，イネカメムシでは小穂軸，ホソハリカメムシでは籾全体で吸汁行動が行われることを明らかにした．そして，斑点米の加害痕の位置の特徴から加害種を推定する方法を提案した．

カメムシ類を放飼した穂における籾の登熟段階と加害籾数との関係を調査して，クモヘリカメムシ，イネカメムシ，アカスジカスミカメは，胚乳が縦伸長途中から幅伸長途中の籾を主に加害し，ホソハリカメムシはより登熟が進んだ籾も加害することを明らかにした．

品種・出穂時期の異なる水田において，小穂をその玄米の発育程度により3段階に区分して，各段階の籾数の推移を調査した．各段階の籾の存在量は，品種・出穂時期によらず出穂始め以降の積算温度によって同様に推移することを明らかにした．そして，積算温度を指標として，カメムシ類の水田への侵入時期やその後の増殖パターンを，品種や移植時期を問わず統一的に表わす方法を提案した．

クモヘリカメムシ密度と斑点米発生数との関係に及ぼす割れ籾の影響を解明するために，水田に設置した網枠内への放飼試験を行って，割れ籾率が5%の場合には，割れ籾が本種による斑点米発生率を上昇させる可能性は低いことを明らかにした．

これらの調査から得られた知見をもとに，クモヘリカメムシの斑点米被害の有無を従属変数とし，す

くい取り捕獲数などを独立変数とした複数のロジスティック回帰モデルを構築し，その中から最適モデルの選択を試みた，そして，幼虫捕獲数のみを独立変数としたモデルが被害予測に最も適していること，登熟初期の成虫捕獲数を独立変数として取り入れたモデルは，幼虫捕獲数を独立変数として取り入れたモデルより被害予測には不適であることを明らかにした．捕獲効率の変動が大きいとされるすくい取り調査であっても登熟中期（出穂開始からの積算気温が200～300日度）の幼虫捕獲数を用いれば被害発生確率を推定できると考えられた．

引　用　文　献

1．Andow, D. A.（1990）Characterization of predation on egg masses of *Ostrinia nubilalis*（Lepidoptera: Pyralidae）. Ann. Entomol. Soc. Am. 83, 482-486

2．有坂通展（1993）割れ籾とオオトゲシラホシカメムシによる斑点米の発生との関係. 北陸病虫研報, 41, 27-30

3．浅井元朗（2002）ムギ作の強雑草カラスムギ-その謎と防除に挑む. 雑草とその防除, 39, 25-28

4．浅井元朗・與語靖洋（2005）関東・東海の麦作圃場におけるカラスムギ・ネズミムギの発生消長とその背景. 雑草研究, 50, 73-81

5．馬場口勝男・深町三朗・瀬戸口　脩（1973）クモヘリカメムシの発生生態ならびに被害解析. 鹿児島農試研報, 1, 42-53

6．De Kraker, J., A. Van Huis, J. C. Van Lenteren., K. L. Heong, and R. Rabbinge（2000）Identity and relative importance of egg predators of rice leaffolders（Lepidoptera: Pyralidae）. Biol. Control, 19, 215-222

7．遠藤亘紀・清水喜一・丸　諭（1977）穂揃期から乳熟期の水田におけるホソハリカメムシとクモヘリカメムシの成虫のすくい取り効率. 千葉農試研報, 18, 105-111

8．藤崎祐一郎（1982）宮城県における水田に生息するカメムシ類と斑点米発生の検討. 宮城農セ報, 49, 45-58

9．福田博年・千代西尾伊彦（1981）カメムシ類に関する研究　（第3報）　山間地水田に発生するトゲカメムシの発生経過と2，3の生態について. 鳥取農試研報, 19, 49-59

10. 福原楢男（1982）水田に見られる直翅目害虫の見分け方（1). 植物防疫, 36, 524-528

11. 福原楢男（1982）水田に見られる直翅目害虫の見分け方（2). 植物防疫, 36, 571-575

12. 福原楢男（1983）水田に見られる直翅目害虫の見分け方（3). 植物防疫, 37, 262-267

13. 福原楢男（1983）水田に見られる直翅目害虫の見分け方（4). 植物防疫, 37, 498-502

14. 福原楢男（1984）水田に見られる直翅目害虫の見分け方（5). 植物防疫, 38, 571-577

15. 船生岳人（2001）おとり田を利用したイネカメムシの耕種的防除の実証. 関西病虫研報, 43, 115

16. 古家　忠・清田洋次（1993）斑点米カメムシの種類と籾の吸汁部位. 九病虫研会報, 39, 82-84

17. 後藤純子・伊藤芳樹・宍戸　貢（2000）水田内におけるヒエ類とアカスジカスミカメ（旧称:アカスジメクラガメ）による斑点米との関係. 北日本病虫研報, 51, 162-164

18. 八谷和彦（1985）アカヒゲホソミドリメクラガメの要防除水準. 北海道立農試集報, 53, 43-49

19. 八谷和彦・橋本直樹（2001）「ほしのゆめ」における斑点米カメムシの要防除水準. 北農, 68, 8-12

20. 浜名光衛（1987）高冷地における水稲の割れ籾と着色米の発生に関する研究. 福島農試研報, 26, 22-32

21. 羽生寿郎・内島立郎（1962）作物の生育と気象との関連に関する研究 第1報 水稲の出穂期と気温との関係. 農業気象, 18, 109-117

22. 長谷川 仁（1961）最近水稲に発生する2,3のカメムシ類. 植物防疫, 15, 143-146

23. 長谷川利拡・宮地好徳・柴垣秀明・高野順也・三浦　学・崎原　健・片野　学（1995）