THE EFFICACY OF CHINCHEX BED BUG INSECTICIDE AGAINST THE COMMON BED BUG, *CIMEX LECTULARIUS*

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The Efficacy of ChinCheX Bed Bug Insecticide against the Common Bed Bug, *Cimex lectularius.*

A report for Mr Agurtzane Pombo

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EXECUTIVE OVERVIEW

- Currently the world is experiencing a major resurgence in bed bug infestations, largely due to insecticide resistance. Bed bugs are now resistant to most of the current commercially available insecticides and there is an urgent need for new products to be registered to combat this important public health pest.
- Desiccant dusts, such as Silicon Dioxide, have many advantages over traditional insecticides, including indefinite shelf life, long residual action, low risk of insecticide resistance developing, and very low mammalian toxicity. Apropos of this, ChinCheX Bed Bug Insecticide (containing 100% Silicon Dioxide, in the form of a dust) was supplied by Mr Agurtzane Pombo to test the efficacy of the product against the Common bed bug, *Cimex lectularius*.
- Three groups of trials were undertaken; the efficacy of ChinCheX to kill unfed adult bed bugs, to kill freshly blood fed bed bugs, and to kill first instar bed bugs. Two bed bug strains were tested: a laboratory insecticide-susceptible (Monheim) and a modern insecticide-resistant strain (Parramatta). ChinCheX was also tested in parallel with Bed Bug Killer (which contains Diatomaceous Earth Dust, a product that is currently registered in Australia for bed bug control), to compare bioequivalence in the three groups of trials.
- ChinCheX Bed Bug Insecticide was found to be highly efficacious against susceptible and resistant strains of the common bed bug, *Cimex lectularius*, and against both adult and juvenile stages.
- ChinCheX produced 100% mortality in all the bed bugs tested.
- ChinCheX produced a significantly faster kill in all the trials than Bed Bug Killer.
- For the non-blood engorged bed bugs (both adults and first instars), ChinChex killed both strains in under 48 hours, whereas it took up to 96 hours with Bed Bug Killer.
- For the blood engorged bed bugs, ChinCheX killed both strains in under 96 hours, whereas it took up to 336 hours with Bed Bug Killer.
- The faster efficacy of ChinCheX means that the client will suffer fewer bites and the infestation is less likely to spread.

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Senior Hospital Scientist &
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3/May/2022

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The Efficacy Testing of ChinCheX to the Common Bed Bug, *Cimex lectularius*.

Background

Worldwide since the beginning of the 21st century there has been a dramatic increase in the number of bed bug infestations, both of the common (*Cimex lectularius*) and tropical (*Cimex hemipterus*) species (Doggett *et al*. 2003, 2004, 2005, Doggett *et al*. 2018). In Australia, during the early part of the new millennium, bed bug infestations increased by some 4,500% (Doggett & Russell 2007, Doggett & Cain 2018) and this trend has been observed in most nations. Numerous suggestions have been offered to account for the return of this public health pest, however it is now recognised that insecticide resistance has been the main contributing cause (Doggett *et al*. 2018). Resistance in bed bugs has been widely reported to multiple insecticide classes (Boase *et al*. 2006, Romero *et al*. 2007, Dang *et al*. 2017).

Unfortunately, most of the insecticides registered around the globe belong to those groups that have demonstrated resistance. This has meant that control is a major challenge and treatment failures have been all too common. Thus, there is an urgent need for new insecticides to become available for the control of bed bugs.

One candidate group of insecticides that have shown promise for bed bug control are the desiccant dusts that include Silicon Dioxide dust (also known as Amorphous Silica) and Diatomaceous Earth dust (DED). These insecticidal dusts have several advantages. Being silica based they have an extremely long shelf; one study found that a silica-based product was still efficacious after 406 days of storage (Tarshis 1962). Desiccant dusts have an extremely long residual action and tends to be nullified only by the built up of dirt, household dust, and other debris. Their mode of action limits the possibility of resistance developing as they has a physical rather than a chemical/metabolic action (Quarles & Winn 1996), in fact the desiccant dusts are not even listed by the International Resistance Action Committee (http://www.irac-online.org/). Desiccant dusts leave no chemical residue (Quarles & Winn 1996) and have extremely low mammalian toxicity, and often recommended by environmental groups. As desiccant dusts have a long residual action, there is a strong potential for these insecticides to be employed as a prophylactic insecticide.

Currently, the mostly widely registered of the two desiccant dusts is DED. However, it is well known that efficacy of this active is much slower than that of silica-based dust (Potter *et al*. 2014), rendering DED a less effective insecticide. The aim of this investigation is to test the susceptibility of the common bed bug, *Cimex lectularius*,

to ChinCheX, a silicon dioxide dust insecticide, in comparison to a DED product (Bed Bug Killer) the latter of which is currently registered in Australia for bed bug control.

Methods

The methods are loosely based on Fletcher & Axtell (1993).

Test Animal

The bed bugs used were the common bed bug, *Cimex lectularius*, and included two strains; Monheim and the Parramatta. The Monhiem bed bugs were sourced from Bayer Germany, with the founder specimens dating from ca.1970. This strain has been found to be susceptible to all insecticides tested to date. The Parramatta strain was sourced from a field infestation in a home in North Parramatta (a suburb of Sydney) during 2012 and is highly resistant to a range of insecticides. This strain possesses both metabolic (Lilly *et al*. 2016) and knockdown resistance (Dang *et al*. 2015) and continues to be highly resistant (Leong *et al*. 2022).

The colony is maintained within 250 mL containers, provided with a blood meal once per week via anesthetised rats, and held at 25°C, with 70% RH and a 12-h photoperiod.

Insecticides

The ChinCheX was supplied by Mr Agurtzane Pombo. No batch number or date of manufacture was provided. Application rate is as per Figure 1, "2 ounces per 150sqf".

The Bed Bug Killer was purchased from a local hardware supplier. No batch number or date of manufacture was listed on the product. Application rate is given as "2-4g/m^2" and the upper concentration was used for the experiments herein.

Experimental Procedures

Three series of experiments were undertaken:

1. Efficacy comparison of ChinCheX and Bed Bug Killer against non-blood fed adults,
2. Efficacy comparison of ChinCheX and Bed Bug Killer against freshly blood fed adults,
3. Efficacy comparison of ChinCheX and Bed Bug Killer against non-blood fed first instar bed bugs.

The bed bugs were exposed to residues of the dusts on Whatman® brand filter paper within Petri dishes (Figure 2). For the adult bed bugs, the tests were

conducted on 90mm filter paper within 90mm x 14 mm Petri dish, and for the first instars, 55mm filter paper with in 60mm x 14 mm Petri dish was used.

Both desiccant dusts were applied at an identical rate of approximately 4g/m^2 (this is comparable to the ChinCheX label rate). For the 90mm Petri dishes, the theoretical amount to be applied was 0.0254g, however 0.03g was applied on the 90mm filter paper as there is some loss of product during the application process (such as in the paint brush used to spread the product over the surface of the paper). For the 60mm Petri dishes, the theoretical amount to be applied was 0.0113g, however 0.012g was applied on the 55mm filter paper as there is some loss of product during the application process. The dust was weighed out on an analytical balance (sensitive to 0.001g) to accurately measure the dust to be applied.

The dust was applied to the filter paper and spread evenly over the surface via a small paint brush. For each treatment, ten bed bugs were placed into each dusted filter paper held within a Petri dish, with a total of four replicates (i.e., 40 bugs in total exposed per treatment). The bed bugs were confined to the treated surface during the experiment. The controls consisted of four replicates of ten bugs on filter paper in Petri dishes not treated with any dust (i.e., a further 40 bed bugs). Mortality was determined at regular intervals by counting bed bugs that did not respond to tactile stimulation. The experiments were conducted at 22±1^{o}C, in a darkened environment, relative humidity of 55±5%.

For Experiment 1, active non-blood fed bed bug adults that had been fed 5-6 days previously were used for the tests. Sex and age of the bed bugs were not determined.

For Experiment 2, the bed bugs were blood fed and only freshly blood fed bed bugs used in the tests (bed bugs had been fed less than 1 hour previously). Sex and age of the bed bugs were not determined.

For Experiment 3, non-blood engorged first instar bed bugs, less than 7 days old were used. It is not possible to readily sex first instars.

Statistical Analysis

Mortality data were pooled and subjected to probit analysis using the PoloPlus program (LeOra Software 2002) to generate LT_{50} and LT_{95} values. The LT_{50}s were considered significantly different ($P<0.05$) when their 95% confidence intervals (CIs) did not overlap (Payton *et al*. 2003, Wheeler *et al*. 2006).

Results

Table 1 contains the LT_{50}s, LT_{95}s, and the statistical analyses of the three experiments.

Experiment 1 (non-blood fed adults): All the bed bugs exposed to both desiccant dusts died, however ChinCheX was significantly faster than Bed Bug Killer in lethality with both bed bug strains (Table 1, Figure 3). All the bed bugs exposed to ChinCheX died within 30 hours, however for Bed Bug Killer, it took 96 hours for all the bed bugs to die. Raw data for the Monheim and Parramatta strains are in Tables 2 and 3, respectively.

Experiment 2 (freshly blood fed adults): All the bed bugs exposed to both desiccant dusts died, however ChinCheX was significantly faster than Bed Bug Killer in lethality with both bed bug strains (Table 1, Figure 4). All the freshly blood engorged bed bugs exposed to ChinCheX died within 96 hours, however for Bed Bug Killer, it took 336 hours for all the bed bugs to die. Raw data for the Monheim and Parramatta strains are in Tables 4 and 5, respectively.

Experiment 3 (first instar bed bugs): All the bed bugs exposed to both desiccant dusts died, however ChinCheX was significantly faster than Bed Bug Killer in lethality with both bed bug strains (Table 1, Figure 5). All the first instar bed bugs exposed to ChinCheX died within 48 hours, however for Bed Bug Killer, it took 96 hours for all the bed bugs to die. Raw data for the Monheim and Parramatta strains are in Tables 6 and 7, respectively.

Discussion

The experiments demonstrated that ChinCheX is highly efficient at killing both susceptible and resistance strains of the common bed bug, Cimex lectularius, as well as all the stages tested.

While both desiccant dusts killed all the bed bugs, ChinCheX produced a significantly quicker kill in all the trials than Bed Bug Killer.

The mode of action of the desiccant dusts is thought to be the result of the waxy surface of the epicuticle being absorbed by the dust, meaning that the insect cannot maintain moisture levels and dies from dehydration (St. Aubin 1991). For this reason, it was felt necessary to test both non-blood fed bed bugs and those that were freshly blood engorged. As expected (due to the mode of action relating to dehydration), the blood engorged bed bugs did take longer to die with both

insecticides, however ChinCheX produced a much quicker kill in both strains (Figures 6 & 7, Tables 1, 4 & 5).

In comparing the efficacy of the desiccant dusts between the different bed bug stages when not blood fed (i.e., non-blood fed first instar versus non-blood fed adults), there was not a significant difference in time to death with ChinCheX (Figures 8 & 9). Thus, ChinCheX was equally effective against the different stages when non-blood engorged. Furthermore, ChinCheX produced a much faster kill than Bed Bug Killer.

The results demonstrate several benefits of ChinCheX over Bed Bug Killer including:

1. The faster kill means that the client is less likely to suffer bed bug bites and the ensuing adverse health effects.
2. A faster kill means that bed bugs are less likely to spread and infest other areas or adjoining premises/rooms in apartments or hotels.
3. As Bed Bug Killer (and DED generally) is slower acting, there is a potential for DED treated bed bugs to repeatedly blood feed, overcoming the desiccant effects of the dust.

Other benefits of the product became evident through the trials. After bed bugs were placed onto the treated surfaces, both desiccant dusts quickly adhered to the insects (Figures 10, 11 & 12). However, ChinCheX is less visible and likely to be more aesthetically pleasing to the customer. Also, it was noticed that Bed Bug Killer formed clumps on the filter paper, whereas ChinCheX did not (Figures 13 & 14). It is possible that by forming clumps, Bed Bug Killer becomes less bioavailable to insects, and this may reduce both immediate and longer-term efficacy.

Conclusion

The experiments showed that ChinCheX is highly efficacious against susceptible and modern resistant strains of the common bed bug, *Cimex lectularius*. Furthermore, ChinCheX produces a much quicker kill than a product containing DED. Thus, ChinCheX should prove to be a useful tool in the arsenal of products available to the pest manager for bed bug eradication.

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Appendix

Figure 1. Product label for ChinCheX insecticide.

ChinCheX®

BED BUGS INSECTICIDE

千赤士 床蝨殺蟲劑

千赤士 床虱杀虫剂

"a extremely effective tool for bedbugs combat"
Dr. Richard Naylor ' PHD University of Sheffield

3 614657 400013 >

500mg

Components

Silicon Dioxide as Amorphous Silica 99.9%

Precautionary statements

Do not use if suffering respiratory condition.

First Aid

Inhalation: Possible discomfort:if cough or sneez move victim to fresh air.

Skin contact: may cause dryness, Wash off with soap and plenty of water, apply moisturising cream.

Eye contact: immediately flush eyes with plenty of water for at least 15 minutes or until all material has been removed.

Ingestion: drink plenty of water.

In case of continued discomfort, obtain medical attention

Kills Bed Bug Adults & Nymphs

Directions of use

- Void using when food is present.
- Apply at a rate of 2 ounces per 150sqf.
- It is recommended the use of gloves, cap, mask and goggles, close all windows and turn off air producing appliances, it is recommended to cover appliances and top surfaces.

Bed Bug Treatment

Remove bedding. Using a brush, apply a fine (nearly non visible) dust coating to mattress edges, bed frame, headboard, all sides of furniture, sofa, sockets edges, door frame and floor edges paying especial attention to introduce inside cracks, crevices and corners. For filling up cracks and/or crevices you can gentle squeeze the bottle pointing its tip towards the area intended When finished, leave the premises and allow 45 minutes for the dust to settle.

Please visit our website: www.chinchex.com for demonstrative videos (highly recommended to improve results) or scan the QR code

KEEP OUT OF REACH OF CHILDREN . POISON

Supplier's Name and Address : Fruit Tree Limited, Flat 06, 4/F , Decca Industrial Centre,12 Kut Shing Street, Chai Wan

Hotline : +852 54176383

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使用說明
使用说明

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二氧化矽為無定形二氧化矽 99.9%

不受干擾下，效果能持續十年 / 快速殺滅床蝨 / 無味•不染色

供家庭使用 / 如患有呼吸道疾病，請勿使用。

急救

吸入：可能引致的不適：咳嗽，打噴嚏 將受害者轉移到新鮮空氣中。皮膚接觸：可能引起乾燥，用肥皂和大量清水沖洗，塗抹保濕霜。眼睛接觸：立即用大量清水沖洗眼睛至少15分鐘，或直至所有材料被移除。誤服，請多喝水。如閣下感到持續不適，請從速求醫

殺死床蝨成蟲及幼蟲

使用方法

當有食物擺放時，請避免使用。以每 150 平方尺計, 請使用2 盎司塗抹。每次使用按需要打開，及建議使用帽子，手套，口罩和護目鏡，關閉所有窗戶及關閉所有產生空氣的電器，建議覆蓋電器和頂部表面。

床蝨處理：

移除床上用品。使用刷子，在床墊邊緣，床架，床頭板，傢私的每面，沙發，插座邊緣，門框和地板邊緣塗抹一層纖細的粉末（幾乎不可見的）。請留意塗抹裂縫或縫隙你可以輕槓壓瓶子然後指向預期的區域。完成後，離開房間，並允許45分鐘的灰塵沉降。建議在第一次使用後10天，再重複此過程。沒有特殊的棄置要求。

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不受干扰下，效果能持续十年 / 快速殺灭床虱/ 无味•不染色 / 供家庭使用 / 如患有呼吸道疾病，请勿使用

急救

吸入：可能引致的不适：咳嗽，打喷嚏 将受害者转移到新鲜空气中。 皮肤接触：可能引起乾燥，用肥皂和大量清水沖洗，涂抹保湿霜。 眼睛接触：立即用大量清水冲洗眼睛至少15分钟，或直至所有材料被移除。 误服，请多喝水。 如阁下感到持续不适，请就医

杀死臭虫成虫和若虫

使用指南

当有食物摆放时，请避免使用。以每 150 平方尺计, 请使用2 盎司涂抹。每次使用按需要打开，及建议使用帽子，手套，口罩和护目镜，关闭所有窗户及关闭所有产生空气的电器，建议复盖电器和顶部表面。

臭虫处理：

移除床上用品。使用刷子，在床垫边缘，床架，床头板，傢私的每面，沙发，插座边缘，门框和地板边缘涂抹一层纤细的粉末（几乎不可见的），请留意涂抹裂缝或缝隙你可以轻磧压瓶子然后指向预期的区域。 完成后，离开房屋，并允许45分钟的灰尘沉降。建议在第一次使用后10天，再重複此过程。没有特殊的弃置要求。

请访问我们的网站：www.chinchex.com获取演示视频

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Figure 2. Photograph of the experimental set up for measuring the efficacy of ChinCheX and Bed Bug Killer against the common bed bug, *Cimex lectularius*. Front two rows in the small Petri dishes are first instars, rows 3 & 4 are blood engorged bed bugs, the last two rows are the non-blood fed bed bugs. ChinCheX is in the four columns on the left, Bed Bug Killer in columns 5-8, and the controls in the stacked dishes on the right. M = Monheim strain, P = Parramatta strain**.**

Table 1. Statistical analyses of ChinCheX and Bed Bug Killer against the Monheim and Parramatta strains of the common bed bug, *Cimex lectularius*.

Chemical	Strain	Stage	N	LT_{50} (95% CI) (hour)	Comparation between insecticides*	Comparation between strains**	LT_{95} (95% CI) (hour)	χ^2 (df)	Slope
ChinCheX	**Monheim**	Adult unfed	40	12.9 (11.5–14.9)	A	a	26.6 (18.8–31.0)	5.9 (5)	5.2±0.5
		Adult fed	40	43.5 (40.0–47.4)	A	b	74.5 (65.8–89.2)	2.1 (3)	7.0±0.9
		First instar	40	13.9 (12.2–16.0)	A	a	33.2 (26.5–48.0)	8.2 (6)	4.4±0.4
	Parramatta	Adult unfed	40	12.4 (11.0–14.2)	a	a	26.9 (21.5–39.5)	5.5 (5)	4.9±0.5
		Adult fed	40	28.8 (26.3–31.5)	a	c	56.1 (48.0–71.5)	0.8 (3)	5.7±0.7
		First instar	40	12.4 (11.1–13.7)	a	a	35.8 (29.5–47.4)	1.9 (6)	3.6±0.7
Bed Bug Killer	**Monheim**	Adult unfed	40	27.7 (24.4–30.5)	B	A	53.4 (45.9–69.4)	2.0 (3)	5.8±0.9
		Adult fed	40	77.1 (67.9–85.4)	B	B	191.8 (165.6–237.1)	1.7 (6)	4.2±0.5
		First instar	40	24.8 (21.9–28.0)	B	A	82.5 (66.5–111.8)	4.7 (6)	3.1±0.3
	Parramatta	Adult unfed	40	33.0 (30.2–36.0)	b	A	58.4 (51.0–72.3)	1.1 (3)	6.6±0.9
		Adult fed	40	96.6 (81.4–111.6)	b	B	182.8 (148.6–284.4)	10.5 (5)	5.9±0.7
		First instar	40	26.6 (23.6–30.1)	b	A	87.7 (70.4–119.2)	3.0 (6)	3.2±0.3

LT_{50}s were considered significantly different ($P<0.05$) from one another based on the 95% confidence interval not overlapping.

*Different letters in the same column indicate a significant difference ($P<0.05$) between the ChinCheX and Bed Bug Killer. Upper case letters are comparing the Monheim strain and the lowercase letters are comparing the Parramatta strain.

**Different letters in same column indicated significant difference ($P<0.05$) between the Monheim and Parramatta strains. Upper case letters are comparing the Bed Bug Killer between the two bed bug strains and the lowercase letters are comparing the ChinCheX between the two bed bug strains.

Mortality in all control groups was below 5% and thus no correction was required.

Figure 3. Comparison of the efficacy of ChinCheX and Bed Bug Killer against unfed adult common bed bugs, *Cimex lectularius*, of the Monheim and Parramatta strains. Note that ChinCheX killed both strains significantly faster than Bed Bug Killer.

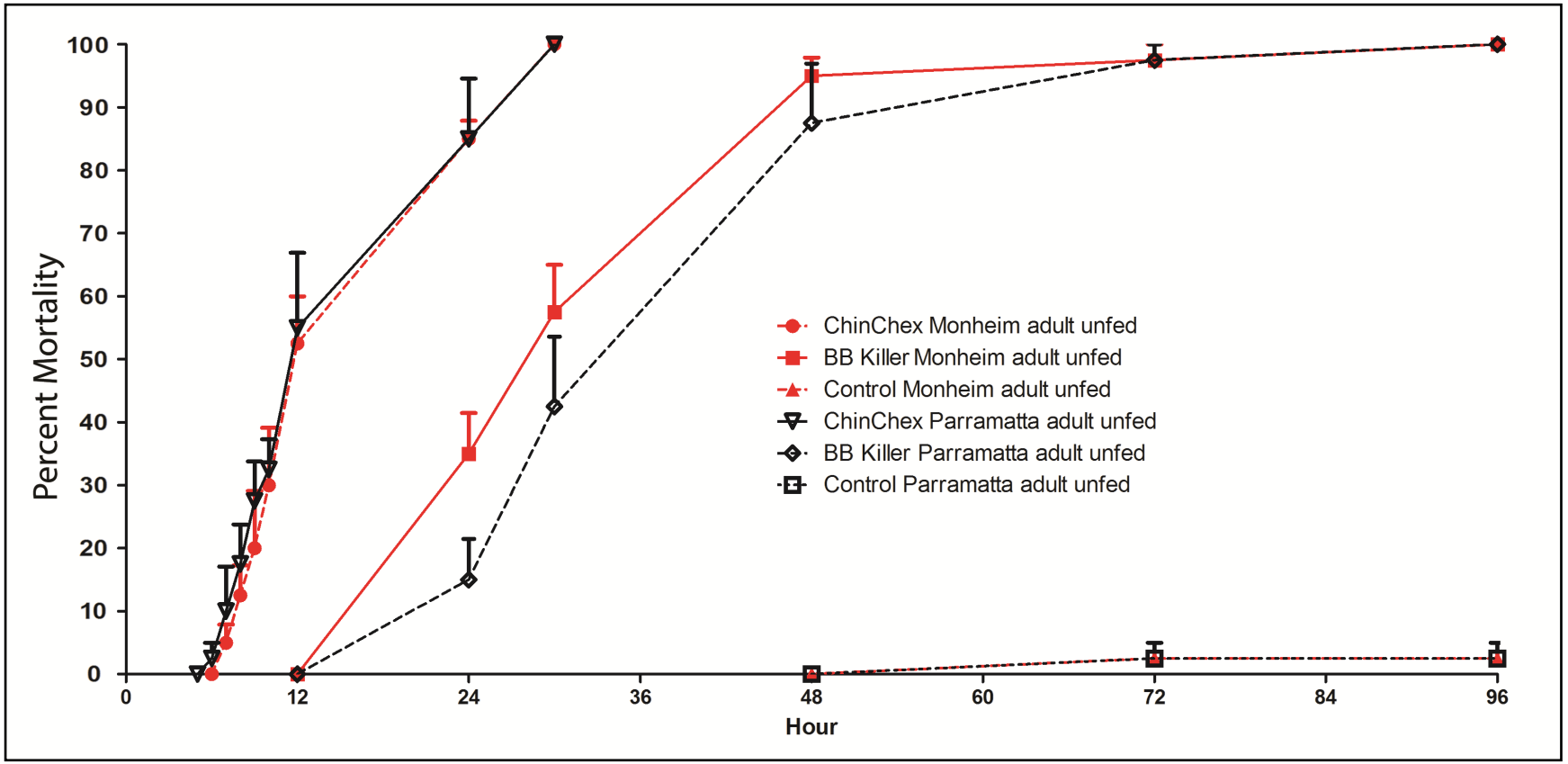

Figure 4. Comparison of the efficacy of ChinCheX and Bed Bug Killer against freshly blood fed adult common bed bugs, *Cimex lectularius*, of the Monheim and Parramatta strains. Note that ChinCheX killed both strains significantly faster than Bed Bug Killer.

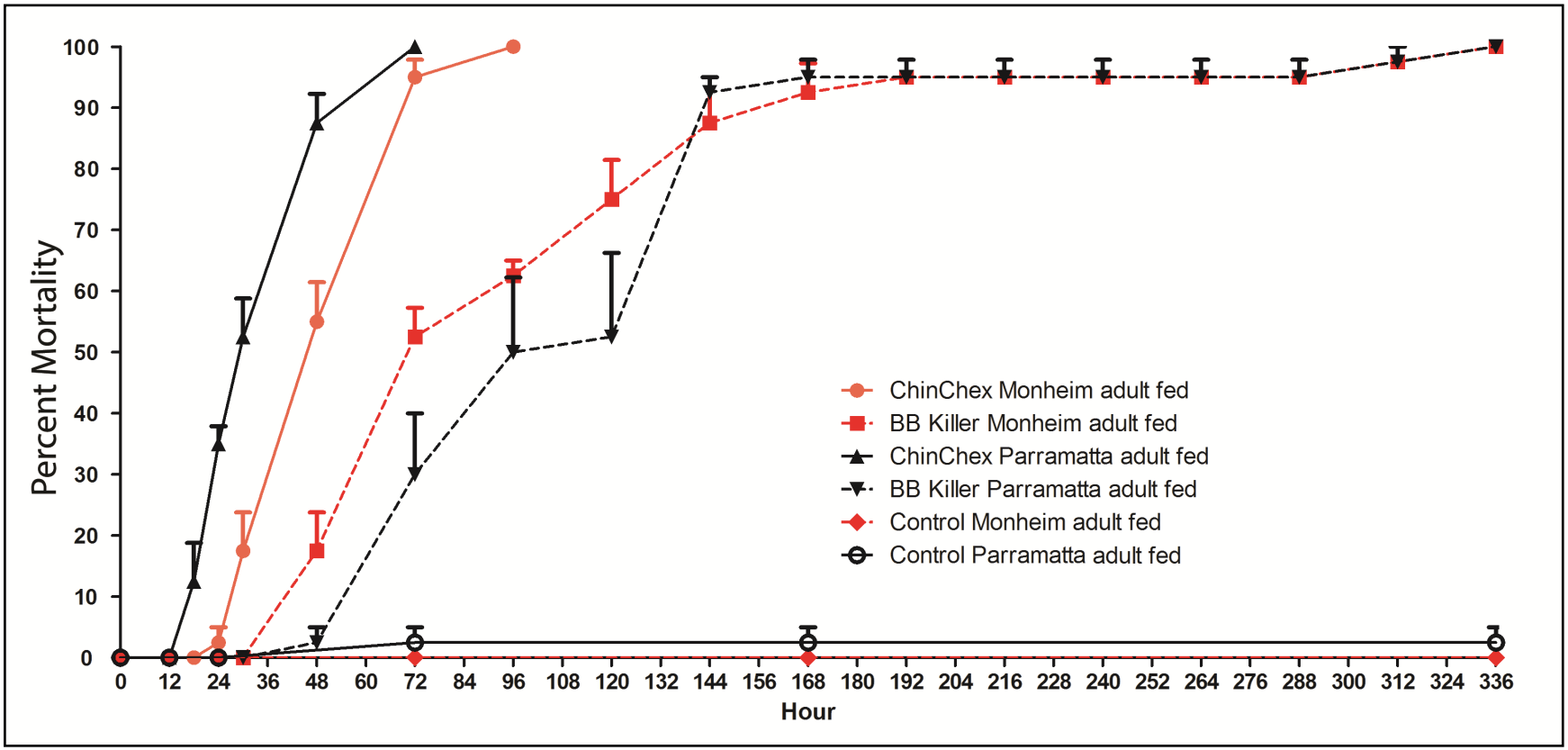

Figure 5. Comparison of the efficacy of ChinCheX and Bed Bug Killer against first instar common bed bugs, *Cimex lectularius*, of the Monheim and Parramatta strains. Note that ChinCheX killed both strains significantly faster than Bed Bug Killer.

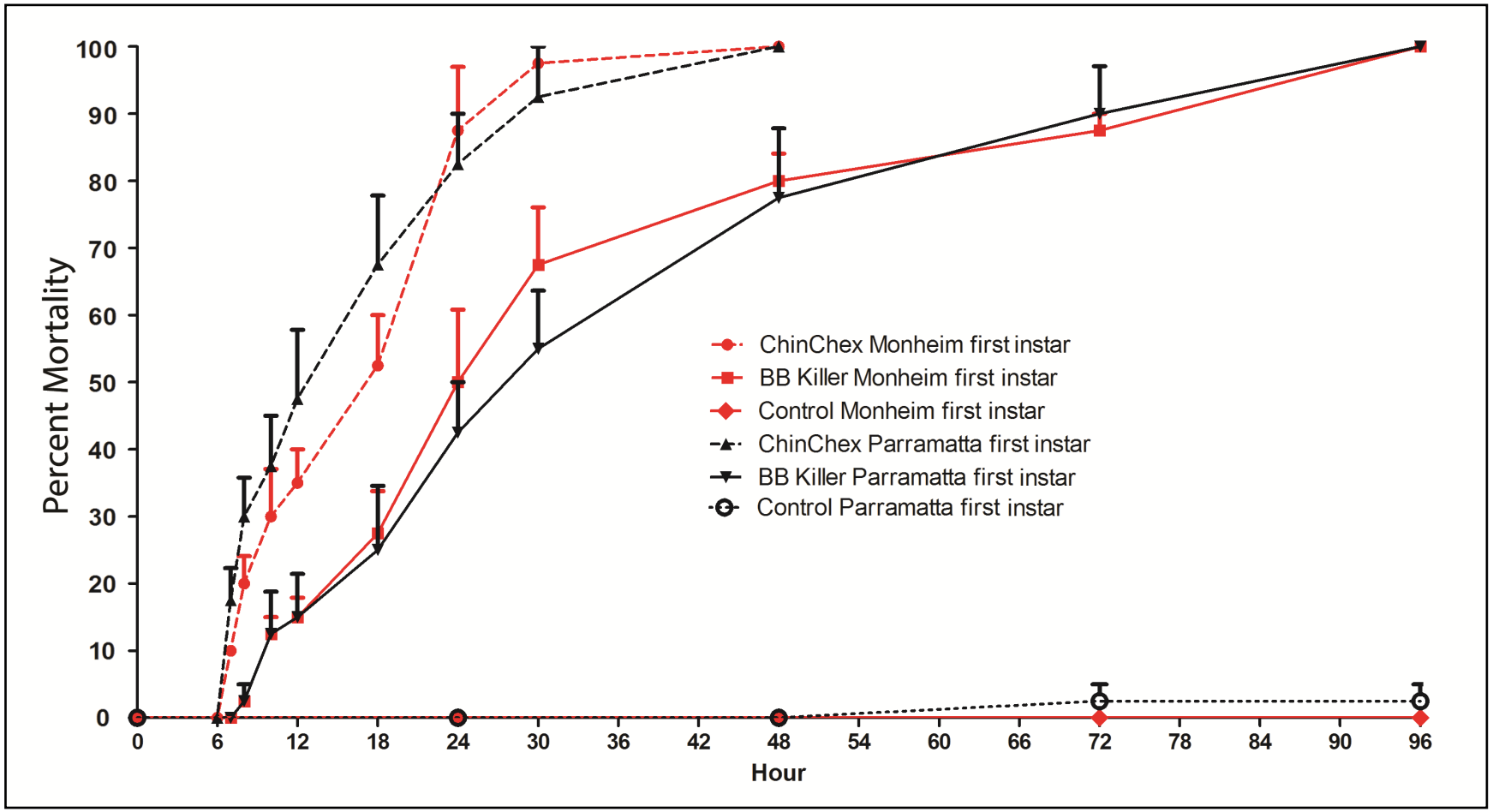

Figure 6. Comparison of the efficacy of ChinCheX and Bed Bug Killer against non-blood fed and blood fed Monheim bed bug strain of the common species, *Cimex lectularius*. Note that ChinCheX killed the bed bugs significantly faster than Bed Bug Killer for each level of blood engorgement.

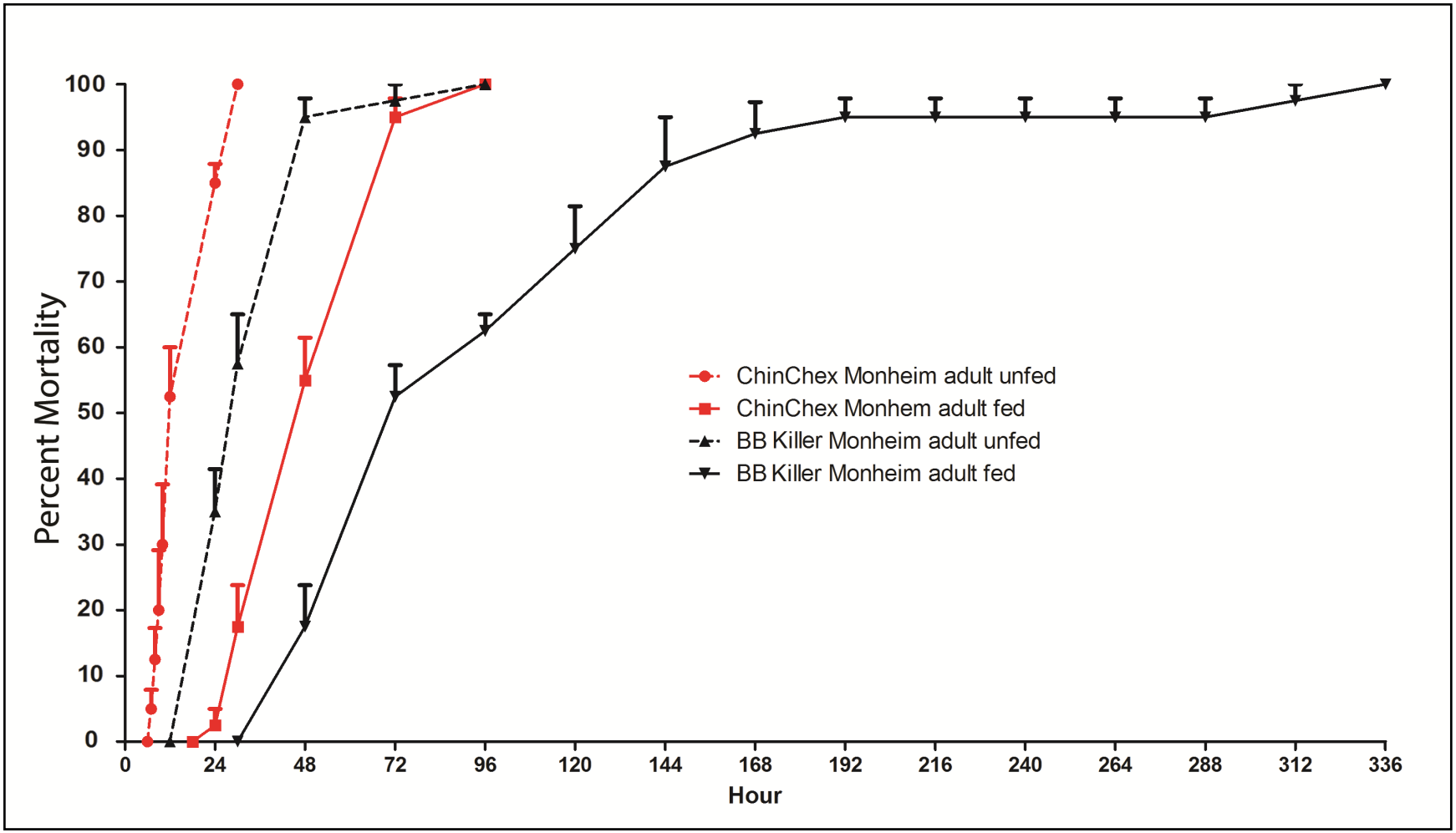

Figure 7. Comparison of the efficacy of ChinCheX and Bed Bug Killer against non-blood fed and blood fed Parramatta bed bug strain of the common species, *Cimex lectularius*. Note that ChinCheX killed the bed bugs significantly faster than Bed Bug Killer for each level of blood engorgement.

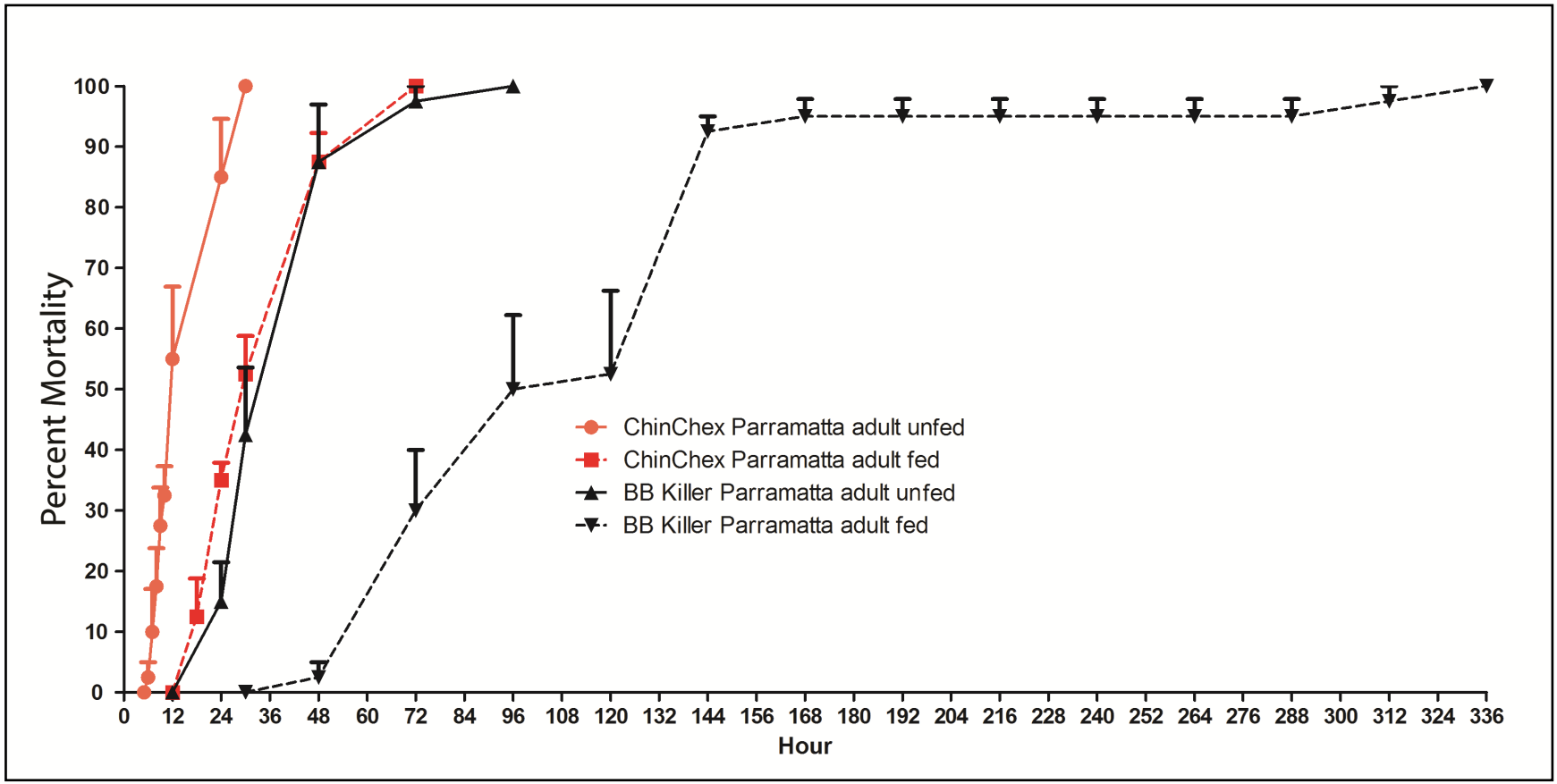

Figure 8. Comparison of the efficacy of ChinCheX and Bed Bug Killer against non-blood fed first instars and adults of the Monheim bed bug strain of the common species, *Cimex lectularius*. Note that ChinCheX killed the bed bugs significantly faster than Bed Bug Killer with both bed bug stages.

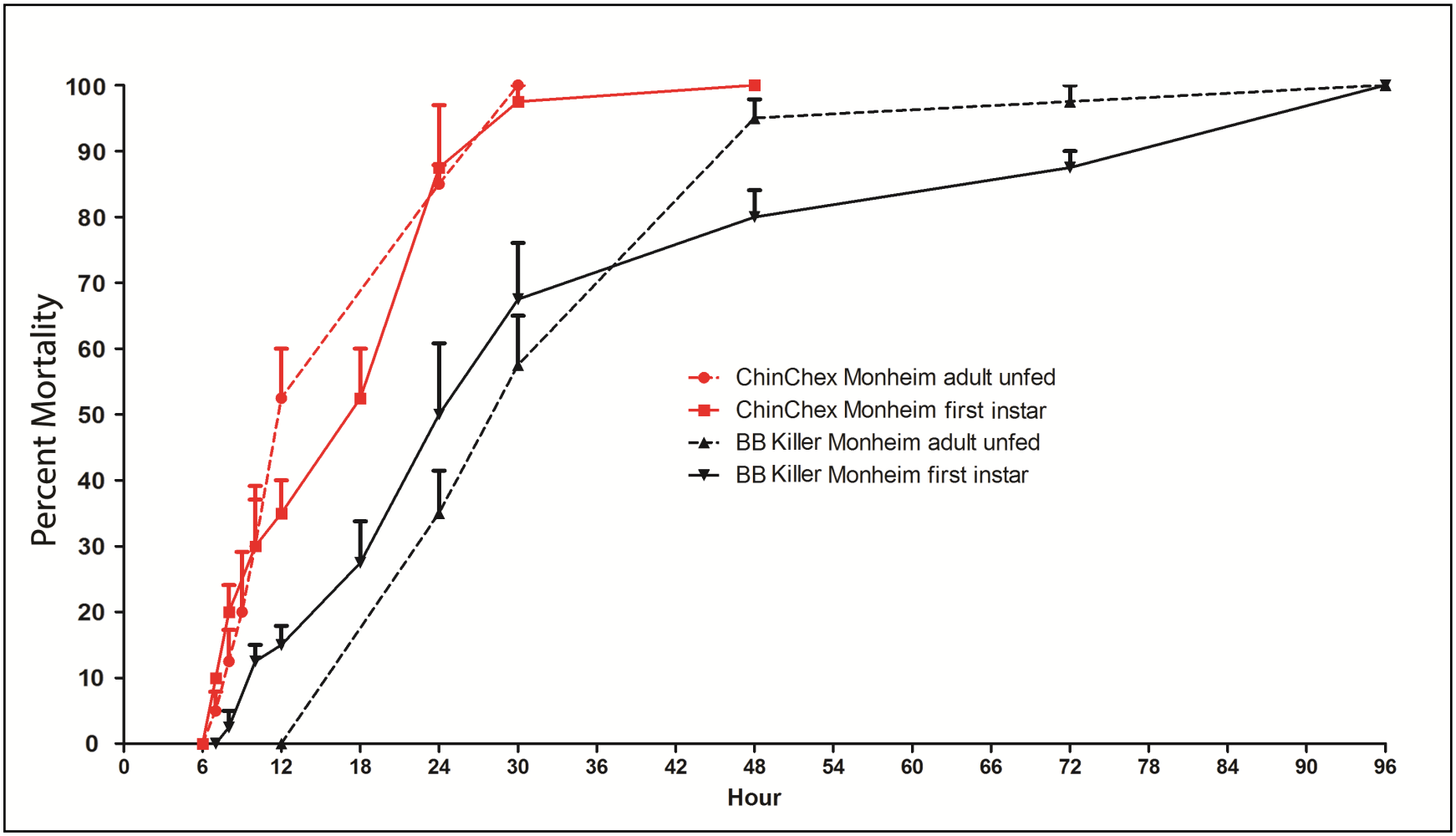

Figure 9. Comparison of the efficacy of ChinCheX and Bed Bug Killer against non-blood fed first instars and adults of the Parramatta bed bug strain of the common species, *Cimex lectularius*. Note that ChinCheX killed the bed bugs significantly faster than Bed Bug Killer with both bed bug stages.

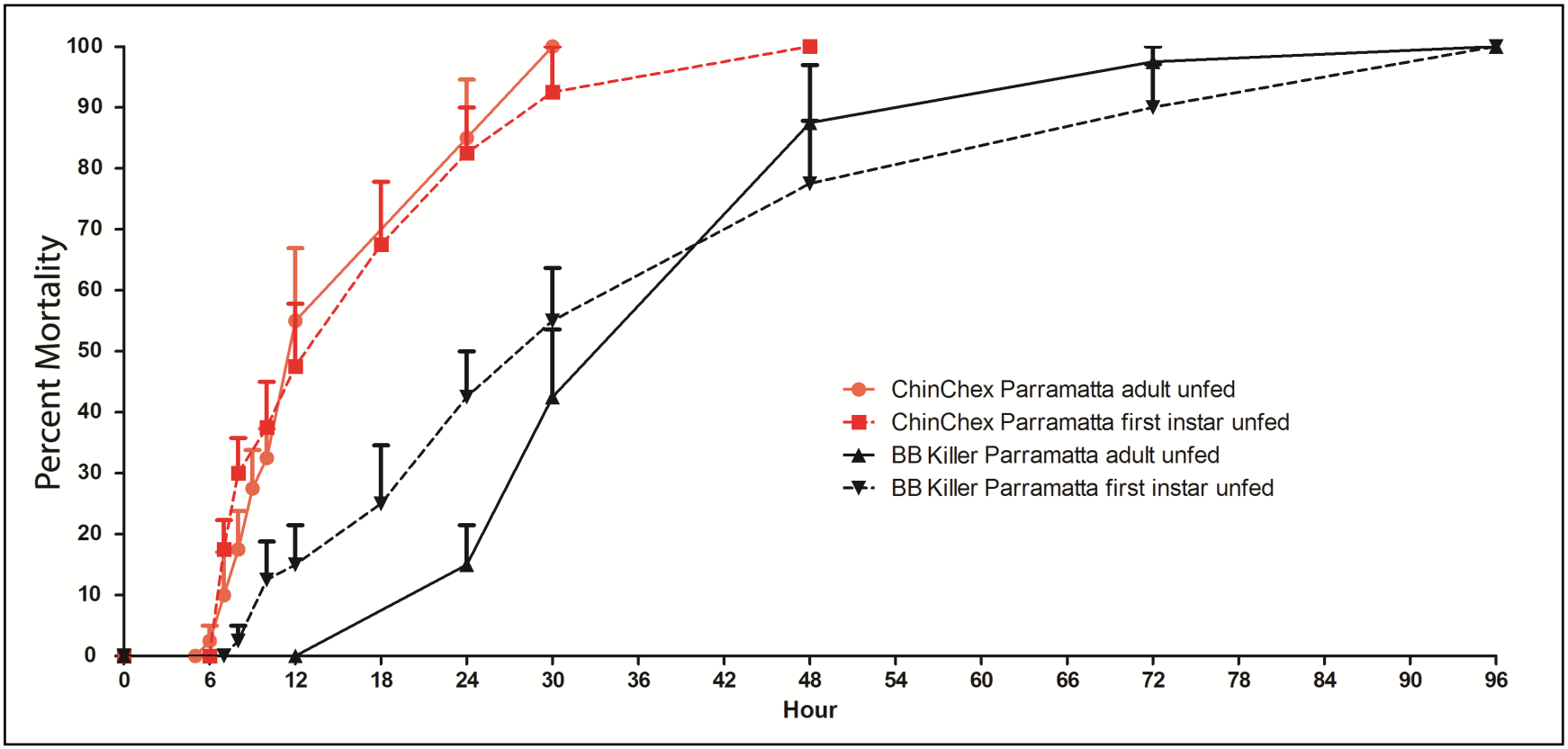

Figure 10. Adult bed bugs, shortly after being added to the ChinCheX treated surface. Note how the dust quickly adheres to the bed bug cuticle.

Figure 11. Adult bed bugs, shortly after being added to the Bed Bug Killer treated surface. This dust also adheres to the bed bug cuticle, but forms discrete lumps, which may render it less bioavailable to the bed bugs.

Figure 12. Dead adult bed bugs, killed by ChinCheX. The ChinCheX dust is not overly obvious and more visibly appealing than the grey Bed Bug Killer.

Figure 13. First instar bed bugs, shortly after being added to the ChinCheX treated surface. The dust remains evenly spread over the treated surface.

Figure 14. First instar bed bugs, shortly after being added to the Bed Bug Killer treated surface. The dust notably forms clumps.

Table 2. Raw data, mortality of non-blood fed adult *Cimex lectularius* Monheim strain exposed to label rates of ChinCheX and Bed Bug Killer, along with the Control (Experiment 1).

Monheim-Adult	Rep.	5 hr	6 hr	7 hr	8 hr	9 hr	10 hr	12 hr	18 hr	24 hr	30 hr	48 hr	72 hr	96 hr
ChinCheX Non-blood fed	I	0	0	0	0	0	1	3		8	10			
	II	0	0	1	2	3	4	6		9	10			
	III	0	0	0	1	1	2	6		8	10			
	IV	0	0	1	2	4	5	6		9	10			
	Tot.	**0**	**0**	**2**	**5**	**8**	**12**	**21**		**34**	**40**			
BB Killer Non-blood fed	I	0	0	0	0	0	0	0		5	8	10	10	10
	II	0	0	0	0	0	0	0		4	5	9	9	10
	III	0	0	0	0	0	0	0		2	5	10	10	10
	IV	0	0	0	0	0	0	0		3	5	9	10	10
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**14**	**23**	**38**	**39**	**40**
Control Non-blood fed	I	0	0	0	0	0	0	0	0	0	0	0	0	0
	II	0	0	0	0	0	0	0	0	0	0	0	0	0
	III	0	0	0	0	0	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**

Rep. = Replicate, Tot. = Total

Table 3. Raw data, mortality of non-blood fed adult *Cimex lectularius* Parramatta strain exposed to label rates of ChinCheX and Bed Bug Killer, along with the Control (Experiment 1).

Parramatta-Adult	Rep.	5 hr	6 hr	7 hr	8 hr	9 hr	10 hr	12 hr	18 hr	24 hr	30 hr	48 hr	72 hr	96 hr
ChinCheX Non-blood fed	I	0	0	0	0	1	2	3		8	10			
	II	0	1	3	3	4	4	8		10	10			
	III	0	0	0	2	3	4	4		6	10			
	IV	0	0	1	2	3	3	7		10	10			
	Tot.	**0**	**1**	**4**	**7**	**11**	**13**	**22**		**34**	**40**			
BB Killer Non-blood fed	I	0	0	0	0	0	0	0		3	7	10	10	10
	II	0	0	0	0	0	0	0		1	3	10	10	10
	III	0	0	0	0	0	0	0		0	2	6	9	10
	IV	0	0	0	0	0	0	0		2	5	9	10	10
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**6**	**17**	**35**	**39**	**40**
Control Non-blood fed	I	0	0	0	0	0	0	0	0	0	0	0	1	1
	II	0	0	0	0	0	0	0	0	0	0	0	0	0
	III	0	0	0	0	0	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**

Rep. = Replicate, Tot. = Total

Table 4. Raw data, mortality of freshly blood fed adult *Cimex lectularius* Monheim strain exposed to label rates of ChinCheX and Bed Bug Killer, along with the Control (Experiment 2).

Monheim-Adult	Rep.	5 hr	6 hr	7 hr	8 hr	9 hr	10 hr	12 hr	18 hr	24 hr	30 hr	48 hr	72 hr	96 hr	120 hr	144 hr	168 hr	192 hr	216 hr	240 hr	264 hr	288 hr	312 hr	336 hr
ChinCheX Blood fed	I	0	0	0	0	0	0	0	0	0	2	5	9	10										
	II	0	0	0	0	0	0	0	0	0	2	4	10	10										
	III	0	0	0	0	0	0	0	0	0	0	6	9	10										
	IV	0	0	0	0	0	0	0	0	1	3	7	10	10										
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**7**	**22**	**38**	**40**										
BB Killer Blood fed	I	0	0	0	0	0	0	0	0	0	0	2	5	6	7	10	10	10	10	10	10	10	10	10
	II	0	0	0	0	0	0	0	0	0	0	3	6	6	6	7	8	9	9	9	9	9	10	10
	III	0	0	0	0	0	0	0	0	0	0	0	4	7	8	8	9	9	9	9	9	9	9	10
	IV	0	0	0	0	0	0	0	0	0	0	2	6	6	9	10	10	10	10	10	10	10	10	10
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**21**	**25**	**30**	**35**	**37**	**38**	**38**	**38**	**38**	**38**	**39**	**40**
Control Blood fed	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	II	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Rep. = Replicate, Tot. = Total

Table 5. Raw data, mortality of freshly blood fed adult *Cimex lectularius* Parramatta strain exposed to label rates of ChinCheX and Bed Bug Killer, along with the Control (Experiment 2).

Parramatta-Adult	Rep.	5 hr	6 hr	7 hr	8 hr	9 hr	10 hr	12 hr	18 hr	24 hr	30 hr	48 hr	72 hr	96 hr	120 hr	144 hr	168 hr	192 hr	216 hr	240 hr	264 hr	288 hr	312 hr	336 hr
ChinCheX Blood fed	I	0	0	0	0		0	0	3	4	5	8	10											
	II	0	0	0	0		0	0	0	4	7	10	10											
	III	0	0	0	0		0	0	1	3	4	8	10											
	IV	0	0	0	0		0	0	1	3	5	9	10											
	Tot.	**0**	**0**	**0**	**0**		**0**	**0**	**5**	**14**	**21**	**35**	**40**											
BB Killer Blood fed	I	0	0	0	0		0	0	0	0	0	0	4	7	7	9	10	10	10	10	10	10	10	10
	II	0	0	0	0		0	0	0	0	0	0	0	2	2	10	10	10	10	10	10	10	10	10
	III	0	0	0	0		0	0	0	0	0	0	4	7	8	9	9	9	9	9	9	9	9	10
	IV	0	0	0	0		0	0	0	0	0	1	4	4	4	9	9	9	9	9	9	9	10	10
	Tot.	**0**	**0**	**0**	**0**		**0**	**0**	**0**	**0**	**0**	**1**	**12**	**20**	**21**	**37**	**38**	**38**	**38**	**38**	**38**	**38**	**39**	**40**
Control Blood fed	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	II	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Rep. = Replicate, Tot. = Total

Table 6. Raw data, mortality of first instar *Cimex lectularius* Monheim strain exposed to label rates of ChinCheX and Bed Bug Killer, along with the Control (Experiment 3).

Monheim-First instar	Rep.	5 hr	6 hr	7 hr	8 hr	9 hr	10 hr	12 hr	18 hr	24 hr	30 hr	48 hr	72 hr	96 hr
ChinCheX	I	0	0	1	3		3	4	7	10	10	10		
	II	0	0	1	1		1	2	4	6	9	10		
	III	0	0	1	2		4	4	6	9	10	10		
	IV	0	0	1	2		4	4	4	10	10	10		
	Tot.	**0**	**0**	**4**	**8**		**12**	**14**	**21**	**35**	**39**	**40**		
BB Killer	I	0	0	0	1		2	2	3	3	5	8	9	10
	II	0	0	0	0		1	1	3	5	7	8	9	10
	III	0	0	0	0		1	2	4	8	9	9	9	10
	IV	0	0	0	0		1	1	1	4	6	7	8	10
	Tot.	**0**	**0**	**0**	**1**		**5**	**6**	**11**	**20**	**27**	**32**	**35**	**40**
Control-First instar	I	0	0	0	0	0	0	0	0	0	0	0	0	0
	II	0	0	0	0	0	0	0	0	0	0	0	0	0
	III	0	0	0	0	0	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Rep. = Replicate, Tot. = Total

Table 7. Raw data, mortality of first instar *Cimex lectularius* Parramatta strain exposed to label rates of ChinCheX and Bed Bug Killer, along with the Control (Experiment 3).

Parramatta-First instar	Rep.	5 hr	6 hr	7 hr	8 hr	9 hr	10 hr	12 hr	18 hr	24 hr	30 hr	48 hr	72 hr	96 hr
ChinCheX	I	0	0	2	4		5	7	9	9	10	10		
	II	0	0	1	2		2	3	5	7	10	10		
	III	0	0	1	2		3	3	5	7	7	10		
	IV	0	0	3	4		5	6	8	10	10	10		
	Tot.	**0**	**0**	**7**	**12**		**15**	**19**	**27**	**33**	**37**	**40**		
BB Killer	I	0	0	0	0		0	0	1	5	7	10	10	10
	II	0	0	0	0		1	2	3	5	6	9	10	10
	III	0	0	0	0		1	1	1	2	3	6	7	10
	IV	0	0	0	1		3	3	5	5	6	6	9	10
	Tot.	**0**	**0**	**0**	**1**		**5**	**6**	**10**	**17**	**22**	**31**	**36**	**40**
Control-First instar	I	0	0	0	0	0	0	0	0	0	0	0	0	0
	II	0	0	0	0	0	0	0	0	0	0	0	1	1
	III	0	0	0	0	0	0	0	0	0	0	0	0	0
	IV	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tot.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**

Rep. = Replicate, Tot. = Total